ANATOMY, SURGERY, PHYSIOLOGY.

THE SCIENCE AND ART OF SURGERY;

Being a Treatise on Surgical Injuries, Diseases, and Operations. By JOHN ERIC ERICHSEN, F.R.S. Senior Surgeon to University College Hospital, Professor of Clinical Surgery in University College, London, &c. The Seventh Edition, enlarged and carefully revised; with 862 Engravings on Wood. 2 vols. 8vo. 36*s.*

A SYSTEM OF SURGERY:

Theoretical and Practical, in Treatises by various Authors. Edited by TIMOTHY HOLMES, M.A. Surgeon and Lecturer on Surgery, St. George's Hospital. Second Edition, thoroughly revised, with numerous Woodcuts, Lithographs, and Chromolithographs; in all 472 Illustrations. In Five Volumes, 8vo. price One Guinea each.

*** Each Volume may be had separately, as follows:—

VOL. I. price 21*s.*, comprises all the articles on GENERAL PATHOLOGY contained in the First Volume of the previous Edition down to the end of 'Collapse,' with the addition of Mr. CROFT's essay on Hectic and Traumatic Fever and the After-Treatment of Operations, which formed part of the Appendix to the previous Edition.

VOL. II. price 21*s.*, comprises all the Treatises in the previous Edition relating to General and Special Injuries.

VOL. III. price 21*s.*: Diseases of the Eye and Ear, of the Organs of Circulation, Muscles, and Bones.

VOL. IV. price 21*s.*: Diseases of the Organs of Locomotion, of Innervation, of Digestion, of Respiration, and of the Urinary Organs.

VOL. V. price 21*s.*: Diseases of the Genital Organs, of the Breast, Thyroid Gland, and Skin; Operative Surgery; APPENDIX of Miscellaneous Subjects; with a General Alphabetical INDEX to the whole Work, and a List of the Authors.

QUAIN'S ELEMENTS OF ANATOMY.

The Eighth Edition. Re-edited by WILLIAM SHARPEY, M.D. LL.D. F.R.S. L. & E. Emeritus Professor of Anatomy and Physiology in University College, London; ALLEN THOMSON, M.D. LL.D. F.R.S. L. & E. Professor of Anatomy in the University of Glasgow; and EDWARD ALBERT SCHÄFER, Assistant Professor of Physiology in University College, London. Illustrated by One Thousand Engravings on Wood. 2 vols. 8vo. price 32*s.*

ANATOMY, DESCRIPTIVE AND SURGICAL.

By HENRY GRAY, F.R.S. late Lecturer on Anatomy at St. George's Hospital. With 411 large Woodcut Illustrations; those in the First Edition after Original Drawings by Dr. CARTER, from Dissections made by the Author and Dr. CARTER; the additional Drawings in the Second and subsequent Editions by Dr. WESTMACOTT. Seventh Edition, by T. HOLMES, M.A. Surgeon to St. George's Hospital; with an Introduction on General Anatomy and Development by the EDITOR. Royal 8vo. 28*s.*

GUNSHOT INJURIES

'Il n'est peut-être pas dans le vaste domaine de la Chirurgie un sujet aussi complexe, qui embrasse un aussi grand nombre de questions pratiques, dont le diagnostic et le traitement exigent de l'homme de l'art des connaissances plus étendues, plus de rectitude dans le jugement, plus d'habileté dans l'exécution, que les blessures par les armes de guerre en général, et en particulier par les armes à feu.'

Leçons Orales de Clinique Chirurgicale, faites à l'Hôtel-Dieu de Paris. Par M. le Baron DUPUYTREN.
Paris: 1832. Tome ii. p. 417.

'Gunshot Wounds are now become almost a distinct branch of Surgery.'
JOHN HUNTER'S Works: *Of Gunshot Wounds.* Ch. i. par. 1.

GUNSHOT INJURIES:

THEIR HISTORY, CHARACTERISTIC FEATURES, COMPLICATIONS, AND GENERAL TREATMENT;

WITH

STATISTICS CONCERNING THEM AS THEY ARE MET WITH IN WARFARE.

BY

SURGEON-GENERAL T. LONGMORE, C.B., F.R.C.S.

HONORARY SURGEON TO HER MAJESTY,
PROFESSOR OF MILITARY SURGERY IN THE ARMY MEDICAL SCHOOL,
ASSOCIATE OF THE SOCIETY OF SURGERY OF PARIS,
ETC. ETC. ETC.

ILLUSTRATED BY FIFTY-EIGHT WOODCUTS.

LONDON:
LONGMANS, GREEN, AND CO.
1877.

LONDON: PRINTED BY
SPOTTISWOODE AND CO., NEW-STREET SQUARE
AND PARLIAMENT STREET

PREFACE.

The subject of Gunshot Injuries and their treatment has acquired a large amount of interest of late years. Neither time, nor money, nor mechanical skill have been spared in promoting efforts to produce guns and rifles of more and more destructive qualities. Nations the most prominent in civilisation have alike vied with each other in struggling to obtain armaments of such numerical superiority, and overpowering weight, as shall enable them the more surely to disable all antagonists to whom they may happen to become opposed. From time to time the improved fire-arms, resulting from these continued efforts to secure military ascendency, have been practically turned to account in national conflicts, and opportunities have been unhappily afforded of observing the injuries inflicted by them in vast and overwhelming numbers.

One result of this experience is to show that gunshot injuries have thrust all other kinds of injuries into the background in modern warfare. Wounds by cutting and stabbing weapons are so few in proportion to them, that they no longer occupy the place of interest among the injuries of war which they held at comparatively recent periods. The number of field-guns has been largely increased in all armies. Portable fire-arms are now almost universally distributed among troops. Not only infantry soldiers, whose special weapon the musket or rifle has always been, but cavalry soldiers, engineers, a certain proportion of gunners, men of the Army Service Corps, all now carry fire-arms of some description. Thus, when war occurs, the injuries resulting from battle which the military surgeon may expect to have to treat are almost exclusively those from gun and rifle projectiles. Nor are they limited to the notice of military surgeons. Irrespective of the

employment of guns for sporting purposes, the practice with rifles and other forms of fire-arms has become so general, that gunshot injuries are now by no means uncommon accidents in civil life. It is for these reasons, and because their special characters are so intrinsically different from those of incised wounds, that I have devoted this work to a separate study of them.

Some persons still cling to the belief that the time for appealing to the arbitrament of war has gone by, that difficulties among the nations which are most advanced in civilisation will in future be solved by laying the questions, to which they owe their origin, before selected judges, whose decision upon them will be submitted to by the disputants as final. The settlement of certain differences of views between Great Britain and the United States by this mode of procedure is quoted in favour of the opinion. Such a consummation as a general agreement to follow this example is heartily to be desired; and it would be gratifying indeed if the practical men of the world could only see good cause for believing in the likelihood of its realisation. But, alas! that it is not so, and cannot be so, unless in rare exceptional instances, is but too evident. All will admit that national conflicts are not rushed into so ignorantly and heedlessly, nor at the dictation of so limited a number of individuals, in our day as they appear to have been in former times; but it is difficult to find any firm resting-place for the belief that the time for their discontinuance is near at hand. Knowledge is more diffused; the terrible evils of war, and the extent to which they spread, are more widely known and more thoroughly appreciated; life is estimated at a higher value; the desire to lessen suffering, and to improve the social condition of the humbler classes, is more generally predominant; there is more to be lost by war, owing to the increase of personal property and the growth of closer commercial relations among nations; and all these circumstances act, up to a certain point, as hindrances to a rupture of peaceful relations between empires and states. But they are impediments that are quickly overcome under the influence of passion and excitement. When Power, in full reliance on its strength, puts forth pretexts for aggression; when there are believed wrongs to be avenged, or rights to be defended; when arguments addressed to reason and prudence, instead of producing a conciliatory feeling, only serve to provoke addi-

tional irritation in the multitude; when the counsel of friends, and even the decisions of arbitrators, are rejected by the disputants; force, in the shape of war, is still made, as it ever has been, the court of final appeal. In social life an irresistible force, which is nothing less than the power of the whole community expressed through its appointed laws and agents, restrains the conduct of individuals under like circumstances; but what force is there so strong as to be able to control the ambitious aspirations and violent actions of nations? All who are of sufficient age must remember how widely, some five-and-twenty years ago, the conviction prevailed in England that nations would no more appeal to arms for the settlement of their disputes, but would submit them to diplomatic management. This delusion vanished before the stern realities of the Crimean struggle. And how many wars since have still further shown the visionary character of that faith! Not to dwell on our own conflicts in the East—the war of the Indian Mutiny, the China Wars of 1857 and of 1860, with the Abyssinian and Ashanti Expeditions—there have been the Italian War of 1859, the great Civil War on the American continent, the Mexican War, the German War against Denmark of 1864, that against Austria in 1866, the war of 1870 between Germany and France, the Turco-Servian War, and now the terrible war, waged with such cruel destruction on both sides, of the Russian invasion of Turkey, the limits and end of which it is as yet impossible to foresee. Truly, our age no more exhibits signs of war having ceased than has the history of man shown that nations ever were content to live for a long series of years at peace with one another. Just as the ruling characteristics of the lower orders of animals and their relations to each other remain unchanged, so among communities of men the powerful still lord it over the weak and seem to resort to force without compunction when passion or apparent interest prompts the attack. The true philanthropist, knowing from the nature of man what consequences, now as heretofore, may be evoked when hostile feelings are aroused, will try, even when armed and ready for strife in defence of right, by the exercise of justice and benevolent consideration for others, to prevent the occurrences which call passions into existence, and so to avert an appeal to violence; but he will neither delude himself, nor try to delude others, with a belief that an era of universal harmony has

been entered upon, and that wars will henceforth be no more. Preparations in all the combatant requirements for war have been and are, in fact, in constant progress among us; and, under such circumstances, the Army Medical Staff, if wise, will also appreciate the need of providing for the future, and making suitable preparations for the special exigencies which it will have to meet should war occur.

> Metuensque futuri,
> In pace, ut sapiens, aptârit idonea bello.

Few men have an acquaintance with the terrible individual sufferings which directly result from battle so thrust upon them as military surgeons. The consequences of war are brought to their notice in an almost infinite variety of forms. If war were truly, as regards the combatants, what poets are too apt to paint it, a matter of glory on one hand or of speedy death on the other, it would not, after all, be nearly so terrible as it really is.

> Concurritur: horæ
> Momento cita mors venit, aut victoria læta.

But, unhappily, army surgeons know too much of other alternatives; not merely the wounds and tortures of the field of action, but also of what follows them—prolonged suffering, sometimes destined to last as long as life itself, and sad mutilations, rendering existence a struggle, or depriving it of all, or nearly all, enjoyment. Army surgeons know so much of these results of gunshot injuries; they have them in such large numbers, and for such long periods, before them; that strange, indeed, must be the feelings of those who are not influenced by an earnest desire to be acquainted with every professional resource that can be turned to account for mitigating such terrible evils.

The extract from the writings of the experienced and distinguished surgeon Dupuytren, which I have placed at the beginning of this volume, expresses very forcibly the difficulties with which the subject of gunshot injuries is surrounded. It is only by previous careful study, by scientific acquaintance not only with the injuries themselves but also with the instruments and forces by which they are produced, and on which their special features depend, and by a knowledge of the experience which has been gained by successive practical observers, that the nature and characters of gunshot injuries can be properly understood, or their appropriate treat-

ment determined. It is essentially necessary for surgeons engaged in military practice to be provided beforehand with this special knowledge. The injuries occur so numerously on fields of battle and in such rapid sequence—to a vast extent, indeed, it may be said, simultaneously—that, to afford efficient aid, the surgeon's decision and action must be ready on the moment. In civil practice there is usually ample time at disposal for studied consideration of each particular injury, as well as for its leisurely treatment; in field practice there is rarely time for deliberation or discussion. Lives depend on assistance being given without hesitation and on the instant. But to be of real service, not only must the urgent demands for surgical aid be met at once, they must also be responded to suitably, according to the special exigencies of each particular case; and that, too, often with very limited material resources at hand. Self-reliance gained from knowledge, the wit to turn everything at hand to account, and previously acquired manual dexterity will alone enable the army surgeon to fulfil his duties on such occasions with benefit to others and with satisfaction to himself.

Military surgeons can never estimate beforehand the number of injuries of the severest character which may demand their attention when warfare is in progress. The statistics which are furnished in a special section of this work show the number of wounds which have been inflicted on certain occasions of battle and in certain wars; but, independently of the fact, elsewhere shown, that these casualties have been very unevenly distributed in regard to special parts of the armies concerned, it is to be remembered that the military surgeons on the conquering side are not only called upon to minister to the wants of their own wounded, but usually have to treat those of the enemy also who are left in the hands of the victors. In the savage condition of man the wounded who fell into the hands of the conquerors were usually treated as spoils of war. No efforts were made to relieve their sufferings or their misfortunes; if badly wounded they were left to die or were killed outright; if they chanced to survive they were used as slaves, or subjected to other indignities. As man has become more civilised he has allowed better feelings to dominate him; and the wounded enemy, whom the fate of war has rendered a prisoner, has been acknowledged to

have a title to some personal consideration. His claim to surgical care and attention has gradually been conceded. These principles have grown in strength as civilisation has advanced, until in recent years the enemy, when wounded and disabled, has almost ceased to be regarded as a foe, and is held to have a right to the same care and attention as the wounded of the conquering forces to whose power he has succumbed. In modern preparations for war, indeed, when rightly conducted, provision of additional surgical and medical materials is usually made to meet such extraneous demands on the resources of the hospital establishments. By the terms of the Geneva Convention—and it is a pleasure to me to remember that I participated in framing them—surgeons of the defeated army may be left to assist in taking care of its wounded without being made prisoners of war, and the necessary ambulance equipment and materials without being captured as prize of war. This treaty has still further increased the means of responding to the demands of humanity on such occasions.

There is another subject, of such serious practical importance when considering gunshot injuries and their general treatment in the field, that I may be pardoned for referring to it here in addition to having dwelt upon it at length in the body of the work. It is that of Field Hospital Organisation, and of the administrative arrangements for the care and disposal of the large numbers of wounded which now commonly result from great battles. It can hardly be said that this subject has ever occupied the important position in military studies in this country which it has deserved to hold. Indeed, until the appointment, subsequently to the Crimean War, of the Royal Commission to Inquire into the Organisation of the Medical Department of the Army, of which the late Lord Herbert was Chairman, it had never received the serious attention of persons in authority. And even as to very recent years, one need only turn to the most approved works on army administration and to the most popular manuals on military matters, written by distinguished officers of the combatant ranks, to discover how small a matter the system of organisation which may be adopted for the care of the wounded has been regarded, if we may judge of the importance attributed to the subject by the space devoted to its consideration.

The operation of collecting, removing, and attending to the first wants of the mass of wounded resulting from a great battle is a vast and serious concern. The manner in which this service is performed is not merely important in respect to preventing aggravation of existing suffering, but the question of life itself, in numerous instances, is involved in the proceeding, and, in many others, the whole future state of the wounded, whether it shall be one of continued pain and of comparative uselessness, or the reverse of these conditions, will be influenced by it. It is a duty which not only requires the necessary amount of transport power, but also thorough organisation, special training, immense energy, and undivided attention, for it to be conducted in an adequate manner. It cannot be treated as secondary or subordinate to other matters of duty, if it is to be executed with anything approaching to that perfection of system under which the fighting services of the army are habitually conducted. Yet it has usually been dealt with as altogether inferior in estimation to other military duties. It has been entrusted to a department of the army, the Quartermaster-General's, which had no training for it, and which is responsible for a large amount of other distinct duties of great military importance. It has always proved impossible for this department to give that amount of attention to this service which, from its nature, it required.

But the removal of the wounded, and a general attention to their first wants, is but a small part of the work which their proper care and treatment demand, when armies are on active service. The duties, administrative and executive, when masses of wounded have to be provided for—when not unfrequently, too, the hospital service is charged with the care of a large number of sick also—are necessarily very onerous and of a very special character. They bear scarcely any resemblance to the duties devolving on medical practitioners who follow their avocations in settled communities, either in the modes of conducting them or in the material appliances employed in their execution. It cannot be said that these functions have ever been discharged by the Medical Departments of Armies in the manner it might well be desired that they should have been in the interests of the wounded; but it can be truly said that, as a rule, they have been performed by them far better than it might have been anticipated the means

at their command, whether of preparation or of execution, would have enabled them to do.

Let a glance be taken at any part of our own army in which special excellence has been achieved, and then let it be ascertained under what system this perfection has been developed. Perhaps there is no more perfect branch of the British Army, whether compared with other branches of its own service or with corresponding corps in the other armies of Europe, than the Royal Artillery. How has it gained this proud distinction? Its officers have not only studied their profession closely, have not only from time to time introduced improvements into the material means by which their knowledge is turned to account in their administrative arrangements, but they have constantly worked them out and tested them under their own supervision. Perfect discipline throughout the grades, complete control within the corps itself over all the parts essential to harmonious movement and efficiency in the whole body, individual daily practice in the use of all details of equipment until thorough acquaintance with them has been obtained, a constant habit of working together, occasional reviews and inspections in the same order as would have to be maintained on active service, have ensured that everything shall be ready, and that every man shall know his business, when the hour of real trial arrives. If a change be made in any part of the mechanical appliances in ordinary use, the organisation exists for at once making it known to all concerned, and for ensuring that steps shall be taken for practical acquaintance with it being acquired through the necessary manipulation. In short, while itself under the control of higher authority in respect to when, where, and to what extent, its functions are to be discharged, and dependent on other branches of the service in matters specially appertaining to those bodies, it has been left free and unfettered in the management of its own duties, and has had full control over all persons engaged in co-operating towards their performance.

Everyone who is acquainted with the position which the Army Medical Department has hitherto held, and who knows the amount of authority with which it has been entrusted over the persons and matériel on which it depends for the due discharge of its duties, must be aware of the immeasurable difference existing between its condition and the condition of that or any other arm

of the service similar to it. Reasons of military or of financial economy may have existed to prevent the medical department from having been entrusted with the same control over its special affairs as other branches of the service; but so long as those reasons existed, it ought to have been remembered that the department could hardly honestly be found fault with for not attaining to the same perfection in its work as those branches had reached in theirs.

A new era is now, however, opening for the Army Medical Service under the present direction of the department. A Warrant, which has appeared since the principal part of this work has been in print, confers on the medical officers of the army the power of controlling all that concerns their special functions, and the limits of this authority appear to be only restricted by those of their responsibilities. Under these circumstances, therefore, it will in future depend in a chief degree upon the medical officers themselves whether their duties are efficiently discharged or otherwise. After the first difficulties, unavoidable under so radical a change, have been overcome, the advantages of the new system should be shown by improvements in the hospital service under the ordinary circumstances of time of peace, but should be made more conspicuously manifest when war leads to the necessity for active employment in the field. It is announced that new medical regulations for field service have been prepared and will shortly be issued. These, when they appear, may be expected to furnish authorised decisions on many of the particular points which have been discussed in the sections of this work on field-hospital administration and equipment.

I believe it to be unnecessary to describe the general plan of this treatise; it is sufficiently shown in the tabular arrangement of its contents. The history of the successive changes which have taken place in the characters of gunshot injuries since they were first presented in warfare will not be found in any special chapters on the subject. It has been sufficiently given, however, in the chapters on the alterations in fire-arms and projectiles to which the variations in their characters have been chiefly attributable. It is believed that this arrangement will have the advantage of being less formal, and of leading to a clearer understanding of their principal features as they are exhibited at the present day.

It will also be noticed that the authorities for some of the statements in the text, together with occasional observations upon them, have been removed to the end of the work, instead of being placed with the text itself, as is more customary. The majority of readers will probably prefer not to be interrupted by references on the same page as the narrative, while those who have a desire for the subsidiary information can readily obtain it by reference to the Appendix. In no case is the information placed in the Appendix essential to the descriptive remarks in the text, but in most instances it is hoped that it will be found of interest to those who may choose to apply to it, either as confirmatory or illustrative of the matters treated upon in the several sections.

Individual injuries incidental to special regions of the body and their particular treatment are not discussed. It would have extended the limits of the work too far to have included them in it. As, however, I have in my possession the necessary materials for the purpose, I hope that at some future time I may be able to supply this deficiency in a separate treatise.

I cannot conclude these prefatory remarks without expressing my acknowledgments to many friends, both in and out of the Army Medical Department, for the readiness with which they have replied to my inquiries for information on various points included in the text. I am also greatly indebted to my friends Professor Macdonald, F.R.S., and Surgeon-Major R. Gillespie, for many of the sketches which illustrate the descriptions in the text; as well as to my friend H. N. Harvey, Esq., of the Ordnance Survey Office, Southampton, for his kind assistance in arranging the index which is placed at the end of the work.

WOOLSTON, near NETLEY:
1st of October, 1877.

CONTENTS.

SECTION I.

GUNSHOT INJURIES, AND THE MEANS BY WHICH THEY ARE PRODUCED.

CHAPTER I.

DEFINITION, NOMENCLATURE, AND GENERAL NATURE OF GUNSHOT INJURIES.

CHAPTER II.

AGENTS CONCERNED IN THE PRODUCTION OF GUNSHOT INJURIES.

CHAPTER III.

ON THE FIREARMS OR OTHER MACHINES, AND ON THE PROJECTILES CONCERNED IN GUNSHOT INJURIES.

CHAPTER IV.

ON LARGE GUNS AND THEIR PROJECTILES.

CHAPTER V.

PORTABLE FIREARMS AND THEIR PROJECTILES.

CHAPTER VI.

ON LIQUID AND GASEOUS PROJECTILES.

SECTION II.

ON THE CAUSES WHICH INFLUENCE THE NATURE, CHARACTERS, PROGRESS, AND ULTIMATE ISSUES OF GUNSHOT INJURIES.

CHAPTER I.

(A) QUALITIES OF PROJECTILES BY WHICH GUNSHOT INJURIES ARE MODIFIED IN THEIR PRIMARY CHARACTERS AND DEGREES OF GRAVITY.

INHERENT PHYSICAL QUALITIES OF PROJECTILES.

CHAPTER II.

CONTINUATION OF THE SUBJECT OF THE CONDITIONS APPERTAINING TO PROJECTILES BY WHICH GUNSHOT INJURIES ARE MODIFIED IN THEIR PRIMARY CHARACTERS AND DEGREES OF GRAVITY.

QUALITIES IMPRESSED ON PROJECTILES BY THE FIREARMS FROM WHICH THEY ARE DISCHARGED.

CHAPTER III.

OTHER QUALITIES WHICH HAVE BEEN SUPPOSED TO EXERT AN ACTIVE INFLUENCE ON THE NATURE AND CHARACTERS OF GUNSHOT INJURIES.

CHAPTER IV.

(B) ON THE CONDITIONS APPERTAINING TO THE PARTS OF THE BODY INJURED BY WHICH GUNSHOT INJURIES ARE MODIFIED IN THEIR PRIMARY CHARACTERS AND DEGREES OF GRAVITY.

SECTION III.

ON THE CHARACTERISTIC FEATURES AND DISTINGUISHING SIGNS OF GUNSHOT INJURIES.

CHAPTER I.

ON THE CHARACTERISTIC FEATURES OF INJURIES PRODUCED BY SOLID PROJECTILES.

Contusions and Wounds.

CHAPTER II.

CHARACTERISTIC FEATURES OF INJURIES PRODUCED BY PROJECTILES OF A GASEOUS FORM.

CHAPTER III.

CHARACTERISTIC FEATURES OF THE INTERNAL TRACKS LEFT BY BULLETS IN DIFFERENT PARTS OF THE BODY.

CHAPTER IV.

CHARACTERISTIC FEATURES OF INJURIES PRODUCED BY SMALL SHOT.

SECTION IV.

ON THE PRIMARY SYMPTOMS AND COMPLICATIONS COMMON TO GUNSHOT INJURIES.

CHAPTER I.

ON PAIN AS A PRIMARY SYMPTOM OF GUNSHOT INJURIES.

CHAPTER II.

ON 'SHOCK' AS A PRIMARY SYMPTOM OF GUNSHOT INJURIES.

CHAPTER III.

ON HÆMORRHAGE AS A PRIMARY SYMPTOM OF GUNSHOT INJURIES.

CHAPTER IV.

LODGEMENT OF PROJECTILES AND OTHER FOREIGN BODIES IN GUNSHOT WOUNDS.

CHAPTER V.

BURNS FROM EXPLODED GUNPOWDER.

CHAPTER VI.

MULTIPLICITY OF WOUNDS.

SECTION V.

AIDS TO THE DIAGNOSIS OF PARTICULAR FEATURES AND COMPLICATIONS OF GUNSHOT INJURIES.

CHAPTER I.

AID TO DIAGNOSIS DERIVED FROM EXAMINATION OF THE COVERINGS OF WOUNDED PARTS OF THE BODY.

CHAPTER II.

AID TO DIAGNOSIS DERIVED FROM EXAMINATION OF PROJECTILES.

SECTION VI.

SECONDARY COMPLICATIONS OF GUNSHOT INJURIES.

CHAPTER I.

INORDINATE INFLAMMATION AFTER GUNSHOT WOUNDS.

CHAPTER II.

GANGRENE AFTER GUNSHOT WOUNDS.

CHAPTER III.

SECONDARY HÆMORRHAGE AFTER GUNSHOT WOUNDS.

CHAPTER IV.

INVASION OF GUNSHOT WOUNDS BY MAGGOTS.

CHAPTER V.

HOSPITAL GANGRENE AFTER GUNSHOT WOUNDS.

CHAPTER VI.

PYÆMIA AFTER GUNSHOT WOUNDS.

CHAPTER VII.

TETANUS AFTER GUNSHOT WOUNDS.

CHAPTER VIII.

ERYSIPELAS AFTER GUNSHOT WOUNDS.

CHAPTER IX.

TRAUMATIC DELIRIUM AFTER GUNSHOT WOUNDS.

SECTION VII.

ON THE ULTERIOR CONSEQUENCES AND DISABLING EFFECTS OF GUNSHOT INJURIES.

CHAPTER I.

CONSEQUENCES OF LODGEMENT OF FOREIGN BODIES IN WOUNDS.

CHAPTER II.

ULTERIOR CONSEQUENCES OF GUNSHOT INJURIES IN PARTICULAR ANATOMICAL STRUCTURES OF THE BODY.

CHAPTER III.

ULTERIOR CONSEQUENCES OF GUNSHOT INJURIES IN PARTICULAR BODILY REGIONS.

SECTION VIII.

GENERAL TREATMENT OF GUNSHOT INJURIES IN FIELD PRACTICE.

CHAPTER I.

FIRST HELP TO WOUNDED.

CHAPTER II.

GENERAL TREATMENT OF WOUNDED MEN ON THEIR ARRIVAL AT A FIELD-HOSPITAL.

CHAPTER III.

LOCAL TREATMENT OF GUNSHOT INJURIES FROM SMALL PROJECTILES.

CHAPTER IV.

LOCAL TREATMENT OF INJURIES FROM LARGE PROJECTILES.

CHAPTER V.

DESCRIPTION OF INSTRUMENTS EMPLOYED FOR DETECTING AND EXTRACTING FOREIGN BODIES LODGED IN GUNSHOT WOUNDS.

CHAPTER VI.

CONSTITUTIONAL TREATMENT OF SOLDIERS SUFFERING FROM GUNSHOT INJURIES.

CHAPTER VII.

TREATMENT OF SECONDARY COMPLICATIONS OF GUNSHOT INJURIES.

SECTION IX.

ADMINISTRATIVE ARRANGEMENTS FOR THE CARE AND TREATMENT OF WOUNDED SOLDIERS IN TIME OF WAR.

CHAPTER I.

ARMY HOSPITAL ORGANISATION.

CHAPTER II.

ARMY HOSPITAL ADMINISTRATION.

CHAPTER III.

HOSPITAL EQUIPMENT.

CHAPTER IV.

SICK-TRANSPORT EQUIPMENT.

SECTION X.

ON THE CLASSIFICATION OF GUNSHOT INJURIES IN GENERAL AND IN ARMY STATISTICAL RETURNS.

CHAPTER I.

ON THE GENERAL NOSOLOGICAL CLASSIFICATION OF GUNSHOT INJURIES.

CHAPTER II.

ON THE SPECIAL CLASSIFICATION OF GUNSHOT INJURIES IN ARMY RETURNS.

SECTION XI.

STATISTICS OF GUNSHOT INJURIES IN WARFARE.

CHAPTER I.

PROPORTION OF HITS TO SHOTS FIRED IN WARFARE.

CHAPTER II.

RATIOS OF WOUNDS TO PARTICULAR PROJECTILES.

CHAPTER III.

NUMBERS AND RATIOS OF CASUALTIES IN VARIOUS BATTLES.

CHAPTER IV.

PROPORTIONATE AREAS OF THE PRINCIPAL DIVISIONS OF THE HUMAN BODY EXPOSED TO BE HIT IN WARFARE.

CHAPTER V.

RATIOS OF WOUNDS IN PARTICULAR REGIONS OF THE BODY IN WARFARE.

CHAPTER VI.

RELATIVE FATALITY OF GUNSHOT WOUNDS IN DIFFERENT BODILY REGIONS.

CHAPTER VII.

PROPORTIONS OF SLIGHT TO SEVERE WOUNDS IN BATTLE.

CHAPTER VIII.

ACCIDENTAL GUNSHOT INJURIES IN TIME OF WAR.

CHAPTER IX.

ULTIMATE RESULTS OF GUNSHOT INJURIES RECEIVED IN WARFARE.

APPENDIX.

ILLUSTRATIONS.

GUNSHOT INJURIES.

SECTION I.

GUNSHOT INJURIES, AND THE MEANS BY WHICH THEY ARE PRODUCED.

CHAPTER I.

DEFINITION, NOMENCLATURE, AND POSITION IN GENERAL CLASSIFICATION, OF GUNSHOT INJURIES.

Definition.—Gunshot Injuries are the injuries which result from the action of missiles set in motion by a force which is derived from the ignition of explosive compounds placed in guns or other suitable receptacles. Regarded as a group, they comprehend every kind and degree of hurt which is capable of being produced on the human frame by the mechanical impulse of obtuse bodies: *non-penetrating contusions*, from the merest bruise of the surface to others, where, although the superficial structures remain unbroken, deeply seated organs are pounded into pulp: and *penetrating wounds*, from the slightest division of the skin to wounds causing instantaneous death by total destruction of the organism.

The term 'Gunshot Injuries' would appear to restrict the hurts so denominated to those which result from projectiles discharged from some of the various kinds of guns and fire-arms, such as cannon, mortars, rifles, pistols, and others in common use. But injuries resulting from missiles projected by explosive force, under a variety of conditions where no kind of gun is employed, are equally comprehended under the same term. Wounds produced

For Notes see Appendix at end of work.

by the fragments of a shell, or of any other case containing gunpowder, the charge or contents of which are accidentally exploded; or by fragments of shells, fougasses, and other such contrivances sunk in the ground, and designedly prepared for the infliction of wounds; wounds resulting from substances propelled by springing mines in warfare, or by the discharge of torpedoes; although nothing of the nature of a gun is employed with them, are ordinarily described as 'gunshot injuries. Up to a comparatively recent period, in all these instances, the explosive material from which the wounding powder has been derived has been gunpowder; but, as other explosive compounds come into general use, even this source of authorisation of the term will be wanting. And, indeed, as regards the essential characters of such injuries, it matters not from what machine the missiles producing them are discharged, or from what material the explosive force arises; neither gunpowder, guns, nor specially formed shot are absolutely necessary to their production; any object propelled with sufficient speed and violence by a sudden expansive force may inflict injuries of precisely the same nature as gunshot injuries. When guncotton is employed as the agent of explosion in fire-arms, the injuries inflicted are completely analogous to those produced when gunpowder is used. There is no difference in the effects of a shot from an air-gun [1] and one from an ordinary fire-arm, other things being equal. The fragments of a water-shell, or of a close iron vessel rent into pieces by the elastic force of steam, are capable of causing injuries of precisely the same nature as those caused by the bursting of a shell exploded by gunpowder. Injuries from pieces of stone projected in blasting rocks afford examples of wounds of a similar description to those produced by stone fragments driven from an embrasure or parapet by shot and shell, or by the explosion of a fougass or torpedo. It is the combination of conditions, by means of which combatants succeed in impressing on missiles, specially formed for penetrating or destroying parts of the human frame, an intensity of active force unattained by any other artificial means, that creates the particular surgical interest which attaches to gunshot injuries when they are individually regarded; it is the peculiarity of the circumstances under which they usually take place, that gives rise to the need of special study of them and of their treatment as they are met with collectively in warfare.

The present work is, therefore, chiefly devoted to the study of gunshot wounds as they come under the notice of surgeons engaged in military practice, but I have thought it well to include in it observations upon the general features of wounds produced by fire-arms of all descriptions, not only by those employed as offensive and defensive weapons, but also those used for purposes of field sport and amusement.

Nomenclature.—The word *Gun*, in the surgical phrase 'Gunshot Injuries,' has not the limited signification which it has in its military definition, but includes rifles, pistols, mortars, and, indeed, fire-arms of all descriptions. It is synonymous with the French 'arme-à-feu,' as the term gunshot injuries is with 'blessures par armes-à-feu.' The French were for a long time more precise than ourselves in their divisions of the 'blessures,' or hurts, into 'contusions par armes-à-feu,' contusions by fire-arms, and 'plaies d'armes-à-feu,' open wounds by fire-arms; the English expression, 'gunshot wounds,' having been commonly employed both for simple contusions as well as for open wounds. A proper distinction between the general term 'injury,' and the specific terms 'contusion' and 'wound' was made in the authorised 'nomenclature of diseases' of 1868, and it is therefore not probable that the terms will be employed otherwise than according to their strict signification in future.

As by far the largest number of wounds resulting from fire-arms in warfare are caused by bullets from portable fire-arms, especially from the different kinds of muskets and rifles, and as these are the wounds which have chiefly attracted the attention of military surgeons, it might have been supposed that these weapons would have furnished the general name for the class of injuries under consideration in this work. The surgical phrase *Gun*-shot injury, however, evidently owes its origin to large guns (mortars and cannon) having been the first kinds of fire-arms by which such wounds were inflicted, and also to the fact of the first *portable* fire-arms having been called 'hand guns,' from their being almost identical in shape and construction with the guns of larger size. Nearly two centuries elapsed after the employment of guns before muskets were introduced, and nearly three centuries before muskets were established as regular implements of warfare. Although in time these latter kinds of fire-arms came to be the most frequent sources of wounds in military operations, English surgical writers, when describing fire-arm injuries, still continued to make use of the phrase which had originally been adopted shortly after the employment of guns and gunshot, and long familiarity with it still makes it the most convenient to employ.

Position of gunshot injuries in general classification, and the principal features which distinguish them from other injuries having affinity with them.—Gunshot injuries—open wounds, as well as non-penetrating contusions—naturally find their place within the general class of 'Contused Injuries.' The latter, indeed, non-penetrating injuries or contusions, resulting from gunshot, differ in no respects from the contusions produced by the strokes of all other blunt instruments. When a fragment of shell, a spent bullet, or other projectile of low velocity impinges upon part of the surface of the body, the condition of the structures which are injured by

the missile is precisely similar to what it would be if the same part had been struck by any other obtuse body, of like size and weight, armed with the same amount of force. It is only, however, in rare and exceptional instances that open contused wounds inflicted by any other instruments than those propelled by sudden violent explosion, present the features characteristic of gunshot wounds.[2] Such instances do occur. The trunk or limb of a person brought into collision with part of a railway carriage moving at 'express' speed is destroyed in the same way as it would be if struck by gunshot; and men and animals are recorded to have been killed on certain occasions by large hailstones, striking them with the accumulated momentum resulting from the force of gravitation, just as if they had been destroyed by a grape shot discharged from a piece of ordnance. Ordinary contused wounds, however, being for the most part produced by agents moving at comparatively low rates of speed, are wounds complicated with injury resulting from overstretching of the divided parts and adjoining structures; if severe, they are accompanied with more or less textural lacerations and ruptures extending far beyond the open wound itself, perhaps with complete disintegration of some of the structures concerned; but they are rarely, if ever, attended with that complete attrition and displacement, and even total removal of substance, which are so constantly characteristic of wounds produced by gunshot. A wound inflicted by a full-sized rifle bullet, at high speed, through some of the softer tissues of the body (the most common kind of wound in warfare, and one that may be taken as typical of gunshot wounds in general), exhibits the open empty track through which the projectile has passed; the walls of the track, or a portion of them, are devitalised by the action of the projectile; disintegrated pulp and dead shreds of tissue, which have been broken up and forced aside by the bullet in its passage, are jammed into these walls; while scarcely any bruising of the surrounding structures beyond is rendered visible, or, indeed, is produced. The same bullet may so glance along the surface of the head as to leave an open furrow from which the hair, scalp, pericranium, and a portion of bone will have disappeared, they having been carried away and dispersed by the bullet in its flight. A grape shot, or piece of shell, at high speed, coming into collision with the soft covering of a limb, leaves a gap just as if the parts detached from the wounded surface had been scooped out by some cutting, though blunt, instrument. Portions of tendons, nerves, and other structures, which, as a rule, escape destruction in the most severe contused wounds produced by ordinary blunt instruments, are liable to be completely destroyed and removed by the action of projectiles. It is this complete attrition, separation, and dispersion of parts of natural tissues opposed to projectiles, together with the existence of certain complications and special features with which gunshot wounds are generally combined,

as will be noticed hereafter, that particularly distinguish them from ordinary divisions of parts accompanied with a certain amount of structural bruising or crushing, and that, further, justify their usual separation into a distinct group, almost as much as the peculiarity of the weapons and projectiles to which they generally owe their origin, and the special circumstances under which they mostly occur and have to be treated in military practice.

CHAPTER II.

AGENTS CONCERNED IN THE PRODUCTION OF GUNSHOT INJURIES.

Preliminary remarks.—It was stated in the preceding chapter, when giving a definition of gunshot injuries, that these hurts are usually produced by (1) an explosive compound fired in a special way in order to provide the necessary force; (2) a weapon, or machine, contrived for giving the required direction to this force, and also to the projectile upon which the force is intended to act; and (3) a body which, being propelled by the force thus generated, becomes the missile upon which the bodily injury directly depends.

In order to study gunshot injuries systematically, it is necessary to consider within certain limits each of the agents which combine in producing them. The first two, however, viz., the explosive compounds and the machines employed in causing wounds, need but very brief remarks in this work. The projectiles to which the injuries are directly attributable are the agents of greatest interest to surgeons, and they must be described and illustrated at greater length. The guns and weapons from which they are discharged can be most conveniently noticed at the same time as the projectiles themselves. The explosive compounds will be treated of in the present chapter.

On the Explosive Compounds employed with Fire-arms, Hollow Projectiles, and other military contrivances.

The explosive compounds chiefly in use.—Various explosive compounds have been employed for propelling projectiles from fire-arms, for bursting shells, for exploding fongasses and mines, and for other military purposes. The chief of these are gunpowder, certain fulminates, and gun-cotton. The many serviceable qualities of gunpowder have caused it to be the explosive agent generally employed. Fulminating powder has only been used for a few special purposes, as in percussion caps and shell bullets. Gun-cotton, as now manufactured, holds an intermediate place between

gunpowder and fulminates: for it has the qualities of force of either one or other of these chemical compounds, according to the mode of its manufacture and the manner in which it is exploded, whether by ignition or by detonation.

Gunpowder.—Depending, as fire-arms do for the most part, upon the projectile force of gunpowder, it will be well to consider briefly what the nature of this force is. So many injuries occur from the action of gunpowder when exploded, contusions, wounds, concussions, burns, and others, and so many instances occur of particles of unexploded gunpowder lodging in parts of the body, that its composition and some of its chemical properties may also be briefly called to mind with advantage.

Without referring to the history of its discovery or of its application to military purposes, both of which seem to be involved in the greatest obscurity, it may be noticed as a curious fact that it has always consisted of the same chemical ingredients as at present, viz., nitrate of potash, charcoal, and sulphur, though not always in exactly the same proportions, nor by any means manufactured in the same manner. The gunpowder used with early fire-arms was comparatively weak from being made of impure ingredients, and from being used in the form of a fine powder, such as is now known under the name of 'meal powder.' Some time elapsed before it was made in the form of coarse grains. Its strength was greatly increased by this change, owing to the opportunity it afforded for the free passage of flame among the particles, and to the ignition in consequence not being limited to the surface of the charge of powder as had previously been the case. Other changes have since been made in the manufacture of gunpowder, all tending to increase its force, and to make this force more manageable under the circumstances to which it has to be applied in warfare. The qualities of the several ingredients of which gunpowder is composed are too well known to be referred to here. Their chemical harmlessness on the human frame was fully discussed in France as early as the time of Ambrose Paré, who demonstrated that gunpowder was unable to confer any poisonous qualities on the projectiles discharged by it, or on the wounds caused by them. Daily proofs are afforded, if any were wanting, of the inertness of gunpowder by its employment in tattooing, and its lodgment with impunity in scattered grains in the skin and subcutaneous tissues of persons exposed to accidental explosions when some of the gunpowder is projected unfired.

Gunpowder explodes at a temperature of about 700° Fahr. The force of the explosion, resulting from the production of gases expanded by the intense heat developed by the chemical action of the combustible ingredients with the nitre, varies according to the conditions under which the gunpowder is fired. Variations in the density of gunpowder, and also in the shape and size of the several

grains—and there are great differences in these respects, especially in the size of the grains in military gunpowder[3]—cause its explosive force to be developed in greater or less time as required. The fact that the gases resulting from the explosion can be made to expand gradually, so as to continue their impulsive action on the shot while it passes along the gun, specially distinguishes gunpowder from fulminates. The total amount of gas resulting from the explosion occupies about 250 times the volume of the original powder. The temperature of the flame produced by the combustion has been variously estimated at from 2,000° Fahr. to 4,000° Fahr., and as the gaseous volume is repeated for every 480° Fahr. of temperature, its increase from expansion by the heat generated during the combustion has been variously estimated from about four to eight times that of the original volume. If the former increase be accepted, the force of the explosion will be in round numbers equivalent to 1,000 atmospheres, or to a pressure of 15,000 pounds on the square inch; if the latter be accepted, to 2,000 atmospheres, or 30,000 pounds on the square inch. The energy of fired gunpowder has been estimated to be even still higher than what has just been named.[4] The force impressed on a rifle bullet or other projectile thus becomes readily intelligible when the enormous amount of sudden pressure to which it has been subjected while confined within the fire-arm is duly considered.

The chemical results of the explosion of gunpowder are 32 per cent. of gaseous products, 68 per cent. of solid residue. The principal gases evolved are carbonic oxide, carbonic acid and nitrogen; the solid residuum consists chiefly of sulphate, carbonate and nitrate of potash, with hyposulphite of potassium and a little unconsumed charcoal. The smoke has nearly the same composition as the residuum just mentioned.

Fulminating powder.—The fulminating composition, chiefly employed for charging percussion caps and explosive rifle shells, is the fulminate of mercury.[5] This highly sensitive fulminate explodes instantaneously and violently by friction or percussion, though, unlike some other fulminates, it burns away quietly when kindled in the open air. It explodes at a temperature of 334° Fahr. The instantaneous conversion of the fulminate into a large volume of gas, and consequently its extremely sudden percussing force if unconfined, and its intense bursting quality if confined, are the characters which chiefly distinguish it from gunpowder as an explosive agent. The gases resulting from the explosion are carbonic acid, nitrogen, and vapour of mercury.

Gun-cotton.—Great efforts have been made since the discovery of gun-cotton in 1846, and are still being made, to manufacture it in such a way that it may be applied to fire-arms as a substitute for gunpowder. Although this desideratum has not yet been achieved, compressed gun-cotton is now employed to serve

numerous important ends, especially in engineering operations, and is included among the regular stores of the army. It is stored under the same precautions as shell, and treated in the same way as filled shells when carried by sea. (Army Circular, Oct. 1870. Control Dept. Cl. 170.)

The early experiments with this agent, both in England and abroad, were attended with so many disastrous accidents that there appeared to be little probability of its ever being brought into general use for military purposes; but means have since been discovered of controlling its dangerous qualities, so that now, if pure, it seems to be no more liable to spontaneous explosion than gunpowder. This control was first obtained by certain methods of structurally arranging the material, devised by Baron von Lenk, of the Austrian service; but has since been more effectively obtained by a plan, devised by Mr. Abel, of Woolwich, of reducing the gun-cotton to pulp, like the pulp of paper, diluting it, according to circumstances, with less explosive materials, and then compressing it into charges of required form and consistence. This prepared gun-cotton has been successfully employed in the same way as gunpowder with portable fire-arms, and is believed by many persons to be likely to be brought into general use in its stead.

The qualities which chiefly give a superiority to gun-cotton over gunpowder for military purposes, are the absence of smoke and of fouling. The gaseous results of the explosion of gun-cotton are transparent, and no solid residuum remains; thus contrasting greatly with gunpowder, which leaves two-thirds of solid residue after explosion. It was at one time doubted whether gun-cotton could ever be practically applied to fire-arms from its yielding vapour of nitrous acid gas, which is eminently destructive to iron; but in the way it is now prepared it only gives out this vapour when it is exploded loose, and then in a very small quantity; when fired under pressure, in the manner in which it is used with weapons of war, it yields none at all. The principal products of its combustion under these circumstances are carbonic acid, carbonic oxide, nitrogen, hydrogen, and aqueous vapour.

The use of gun-cotton is calculated to facilitate military operations in other ways besides its freedom from smoke and fouling. The disruptive force, as for bursting shells, is six times greater than that of gunpowder; its propelling force, as a charge in fire-arms, three times greater, one part by weight in gun-cotton carrying a shot as far as three times the same weight in gunpowder. It may be wetted without damage; for on being dried again in the open air, it is as good for use as it was before. It explodes at a temperature of about 277° Fahr. The character of the explosion varies according to circumstances. When ignited in the open air gun-cotton burns like an ordinary inflammable substance; when gun-cotton is confined and ignited by the intense sharp action of

a detonator, such as by a fulminate, it explodes with sudden and extreme violence: when pulpified, compressed into dense cakes and dried, it explodes after the manner of gunpowder. It does not heat guns as the explosion of gunpowder does. This last quality will greatly facilitate the opportunity of discharging repeated volleys of shot from fire-arms. The great difficulty yet to be overcome seems to be its tendency to decompose under various circumstances after long keeping, when it ceases to be manageable as an explosive agent for military purposes.

Dynamite.—There is another explosive which has recently been used in military operations, viz., prepared nitro-glycerine, or dynamite. The Germans employed it during the late campaign in France in blowing up buildings and bridges, and also as a bursting charge in shells. A mode of preparing it has been devised which renders it free from danger in manipulating it or in transporting it from place to place. This immunity from danger is obtained by a process very similar to that by which Mr. Gale succeeded in rendering gunpowder non-explosive at pleasure, without injuring its explosive qualities when they were required to be employed, viz., by temporarily mixing with the gunpowder a certain proportion of granulated glass. In the case of the nitro-glycerine, a certain proportion of fine sand is mixed with it, about one quarter of its weight. Under these circumstances the composition will not explode from the action of heat alone nor from concussion alone. When placed in a case, and set fire to, it burns without any report or explosion, without smoke, and with a flame resembling that of spirits of wine. But when fired by means of a fulminate, when it is suddenly subjected in this way to the conjoined action of the heat of a spark and a violent percussion, it explodes with great violence. Its explosive force under such circumstances is said to be about eight times that of gunpowder. In a missile therefore of the nature of a shell sufficient dynamite for filling the eighth part of the space that would have to be occupied by its usual charge of gunpowder, would suffice to produce the same bursting effects; and by a little increase in the quantity of dynamite, in case of the shell being made proportionally thicker, without altering the diameter of the shell, the fragments into which it would become broken on explosion would be more massive and heavy, and consequently be capable of effecting greater destruction on striking any objects opposed to them.

Picric powder.—Experiments made in England about the year 1872 led to the proposal that this powder should be used as a bursting charge for shells. It is a mixture of picrate of ammonia and nitre. It has more violence of action, and did not appear to be more liable to explosion from the effects of friction and concussion than ordinary gunpowder. Whether this or any other similar explosive agent, however, will be able to resist with suffi-

cient certainty the effects of the concussion to which a shell is unavoidably subjected upon the explosion of the charge used to propel it from the gun, can only be determined by more extensive practical experience than has yet been given to the subject.

CHAPTER III.

ON THE FIRE-ARMS OR OTHER MACHINES, AND ON THE PROJECTILES CONCERNED IN THE PRODUCTION OF GUNSHOT INJURIES.

For what reasons, and to what extent, acquaintance with this part of the subject is necessary for military surgeons.—A particular knowledge of gunnery or the laws of projectiles does not concern military surgeons, but it is necessary for them to possess some acquaintance with the nature of the principal kinds of fire-arms and shot, and the peculiarities of their construction. Whatever increases in a marked degree the velocity of movement, force, and range of projectiles, whether it be alterations in the projectiles themselves or in the fire-arms from which they are discharged, changes proportionably the features of the injuries inflicted by them, and, within certain limits, the treatment necessary for their cure. The military surgeon ought, therefore, to have an idea of the rates of velocity and other characteristic features of projectiles, in order that he may attain to a correct understanding of the nature of the injuries inflicted by them. The knowledge further enables a surgeon to recognise and describe more correctly these injuries when he meets with them in practice; and it is to be remembered army surgeons are required to specify in the Returns of Wounds, which have to be furnished after engagements, the particular projectiles by which the wounds have been caused.

The student of gunshot injuries requires, further, to know something of the history of the successive changes which have taken place in fire-arms and fire-arm projectiles from time to time, so that he may be able to understand the different descriptions which have been given of them by surgeons at different periods. It would be difficult for a surgeon, whose observations were solely derived from witnessing the effect of the weapons and projectiles used in warfare at the present time, to understand some of the observations of John Hunter on the subject; neither would many passages in the writings of surgeons, engaged in practice even during so comparatively recent a period as that of the Peninsular War, be clearly understood without the student being informed of the qualities of the guns and projectiles by which the gunshot wounds were at that time inflicted. But it is only so far as they may be supposed to have exerted an influence on the nature and

circumstances of the wounds caused by them that a knowledge of the changes which have taken place in the construction and arrangements of fire-arms is important to military surgeons; and they will only be so far noticed in the present work as to meet the requirements which have just been mentioned.

General classification of projectiles considered as sources of gunshot injuries.—Gunshot injuries are produced by two classes of projectiles: *direct* projectiles, those which are projected directly by a *primary* explosive force; and *indirect* projectiles, those which are secondarily impelled by projectiles of the former kind, and are afterwards brought into collision with the persons wounded by them.

A direct projectile has impressed upon it at first starting a momentum corresponding with the whole of the force by which it has been discharged from the fire-arm, or is otherwise projected; an indirect projectile has impressed upon it at first starting only so much momentum, or a share of it, as was retained by the direct projectile at the instant it was struck by it, *minus* the force which had to be expended in overcoming the resistance in propelling or rending it from the situation it had been occupying previously to its removal.

Of the *direct projectiles*, some have definite, others indefinite forms. The projectiles which have definite shapes are the several varieties of gunshot, shell (before explosion), rockets, bullets contained in canister shot, &c.; and the various kinds of bullets and shot discharged from portable arms, such as rifles, carbines, and pistols. The direct projectiles of indefinite shape are such as result from the explosion of fougasses, torpedoes, mines, tumbrils, magazines, or from the bursting of any case by the firing of explosive materials enclosed in it, when the case itself has not been previously set in motion by some primary force of impulsion. Unexploded grains of gunpowder fall under this last-named category. When shells, discharged in the ordinary way, are burst asunder, the fragments and the contents of the shell, if any exist, cease to possess purely the characters of direct projectiles, for the primary forces by which they have been projected are to a certain extent modified by the effects of their bursting charges, as will be notified hereafter.

The *indirect projectiles*, which give rise to injuries in warfare, are very various in their nature: stones or other hard substances struck from parapets, or from the surface of the ground, by gunshot; splinters of iron and wood torn in a similar manner from guns, gun-carriages, platforms, embrasures, timbers of ships, &c.; parts of metal accoutrements, fire-arms, and other articles, carried by soldiers in adjoining ranks; even portions of the bodies of wounded comrades; together with fragments of a variety of miscellaneous objects ordinarily employed in open field warfare, which

have happened to be smashed and scattered by shot or shell in the course of the flight of these projectiles.

Foreign bodies accompanying projectiles in gunshot wounds.—Portions of clothing, or other articles worn or carried by wounded persons, or fragments detached from parts of the bodies of wounded men, when they have been detached by projectiles and are forced to accompany them into the parts which they have wounded, cannot properly be regarded as being themselves projectiles, even of the indirect kind. They do not produce the wounds. Such foreign bodies are with more propriety classed among things which act as primary complications of gunshot wounds.

Classification of particular projectiles.—The projectiles discharged from fire-arms may be most conveniently considered in a surgical work under two groups, viz.:—

(A) *Large projectiles*, discharged from heavy arms of large calibre, such as guns, mortars, &c.; or otherwise propelled, as rockets; and

(B) *Small projectiles*, discharged from portable fire-arms, such as rifles, pistols, &c.; or from machine guns with barrels of small calibre, as mitrailleurs.

CHAPTER IV.

LARGE GUNS AND THEIR PROJECTILES.

Guns.—Very few remarks are necessary in respect to the guns from which the larger kinds of projectiles are cast, as their shape and construction have not the same influence in determining the *features* of wounds as is exerted by the corresponding qualities of the smaller kinds of fire-arms. The improvements which have been made in them have had for their objects increased power of projection, accuracy of aim, mobility, and facilities for multiplying the rate of fire.

Guns, or, as they were originally called, bombards,[6] afterwards popularly designated 'cannon,' are the oldest kind of fire-arm. They were originally like mortars in shape, being wider at the mouth than in the bore or at the breech. Guns are stated to have been used in the English army, under Edward III., as early as 1346[7]; some writers mention a still earlier date. They appear to have been often cast of immense size,[8] and to have been at first made more with a view of throwing huge stones and battering the buildings of besieged places, than with the intention of inflicting wounds among troops in the open field. The alterations in guns since the early periods just referred to have principally consisted in giving to them a more scientific construction, and it is not

necessary to follow them through these changes. Guns of enormous weight and dimensions have been constructed of recent years. The latest of this character in England has been the 81-ton gun, 27 feet long, with a bore of 16 inches, expending a charge of powder of above 300 lbs., throwing a projectile 1,700 lbs. in weight, and striking a blow of 26,300 'foot-tons.' But this has been outdone by the Italian 100-ton gun, with its projectile, 2,000 lbs. in weight, and a developed striking energy of 31,000 foot-tons. It is difficult to imagine where this monstrous competition will come to a halt. The struggle does not, however, concern surgeons: the wholesale ruin and destruction these gigantic weapons are designed for, if accomplished, will leave no scope for surgical help.

Large projectiles.—As regards the projectiles used with field guns, the surgeon will not fail to notice that, excepting in certain projectiles designed for special objects, the changes which have been successively made in them have had constantly for their object increased power of destructiveness, particularly in respect to capability of multiplying the number of wounds and injuries inflicted at each discharge. Thus, from the imperfectly formed stone or iron round shot of the earliest periods, inventors proceeded to fashion rude shells, which were again followed by the more perfect shrapnell and segment shells, each successive form having been specially designed and contrived for increasing the number of injuries capable of being made by it. These qualities in the projectiles, together with the increased force of projection, and facilities of rapid fire obtained by the improvement in the guns from which they are discharged, have been the chief means by which the area of injury as well as the numbers of killed and wounded have been from time to time magnified within given periods of time, and by which the difficulties of surgical administration in the interests of the wounded have been greatly augmented.

Although there are few of the large projectiles which have been in ordinary use of late years that are not now passing away, the most modern forms being almost wholly confined to the cylindro-conoidal shell and case-shot, yet a brief description of them is of historical interest, and, indeed, necessary, for they are constantly referred to in the works of the best writers on military surgery of the present century. Examples of many of them too are still to be found in some armies.

The projectiles of large size used in warfare have been technically distinguished under the names of shot, shell, carcass, and rockets. Numerous varieties of each of these classes of projectile have been in use, with the exception of the carcass. The leading varieties only will be noticed.

Gun shot.—The ordinary gun shot in use a few years ago were formed of solid masses of metal, projected either singly or collectively. When used singly they were sometimes called *loose shot*,

when collectively, they were called *grape shot*, and *case*, or *canister* shot.

The *loose shot* were usually spherical in form, when they were called *round shot* [9]; with the Whitworth guns they were hexagonal, either with tapering ends or flat-headed, and were often spoken of as *bolts*.[10] These projectiles varied in weight in the British service from a shot a little under 3 lbs. in weight for a three-pounder gun, to that of the twelve-inch gun, 600 lbs. Solid shot of the cylindro-conoidal form, and projected from rifled guns, have been used in the British service, but only for battering purposes.

Round shot.—These projectiles in the early days of fire-arms were made of stone, but for many years past have consisted of solid spheres of cast iron. Occasionally they have been made for special purposes of steel or of chilled iron (*chilled shot*).

Red-hot shot.—Solid shot have sometimes been heated to a red heat before being fired. They were then used against shipping, magazines, or buildings, more for incendiary purposes than for inflicting wounds. They are not likely to be used in future, as the Martin shell, which contains molten iron, has been stated to be a far more effective projectile of the kind.

Grape shot.—Grape shot for some years consisted of a certain number of round cast-iron shot, nine or more, according to the size of the projectile, held in three layers between four tiers of circular iron plates. These plates were connected by a central rod or spindle, the latter being secured at one end by a nut and screw. The iron discs had holes bored through them for receiving the shot, which were thus rendered more secure in their position. This projectile was known in England as Caffin's grape (fig. 1). It was largely employed by the Russians during the Crimean war in the defence of Sebastopol. The instant such a grape shot quits the mouth of the gun, owing to the manner in which the explosive force is impressed on its different parts, the nut in front is forced off the screw, the plates successively follow, and both shot and plates are more or less scattered in their onward flight. The flat discs soon fall to the ground in consequence of the resistance of the air, while the shot have a considerable range.

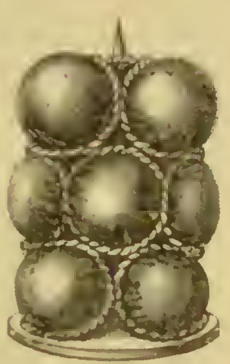
FIG. 1.

Caffin's Grape.

At a former period, all grape shot projectiles were made up in a canvas bag, and the bag being tied round and round, 'quilted,' so as to secure the shot from shifting out of their respective places, an appearance somewhat resembling a bunch of grapes was presented—hence the name (fig. 2). This was the kind of grape shot which was in common use in the British service during the Peninsular and other wars of the present century prior to the Crimean

war, and to which reference is frequently made in the accounts of naval actions of the same period. Old stores of this projectile were turned to account by the British army during the Crimean war, though the kind known as Caffin's grape was chiefly employed.

Fig. 2.



Quilted Shot.

Grape shot varied in weight according to the size of the gun from which they were intended to be discharged. In a 32-pounder gun the weight of the whole shot was 36 lbs. 4 ozs., the nine grape comprised in it each weighing 3 lbs., and the plates, spindle, and screw, 9 lbs. 4 ozs.

Grape shot is now superseded by case shot or case grape.

Case, or canister, shot.—These projectiles consisted of closed cylindrical cases (fig. 3) made of sheet iron, and filled with iron balls of different sizes according to the nature of the case shot employed. From the same causes that led to the separation and dispersion of grape shot, the canister holding the encased shot was torn asunder at the moment of quitting the gun's mouth by the shock of the discharge, and its fragments and the shot which were contained within it were then forced onwards independently, the scattered shot assuming, as a whole, the area of a cone. The destructive effect of case shot was confined to comparatively short distances—from 300 to 350 yards. They were designed for use against troops in close masses.

Fig. 3.

Case Shot.

Case shot were used of various sizes, and the projectiles within the case were also of various weights. The case shot for a 32-pounder gun weighed nearly 36 lbs.; it contained 66 shot, each shot being 8 ozs., or a total of 33 lbs.; the iron case and wood bottom made up the remainder of the weight.

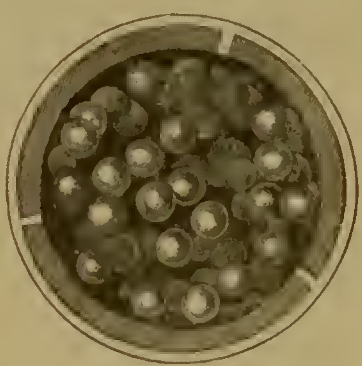
Wounds from discharges of 'langridge,' or 'langrel,' are occasionally alluded to in surgical reports, especially those connected with naval warfare. Langridge was canister shot in a primitive form. It appears that very early in the art of gunnery, artillerists employed charges of small stones, nails, and other irregular substances, packed together in bags, as projectiles under this name. Similar contrivances were frequently employed by the rebel sepoys, during the Indian Mutiny, in default of projectiles of more regular form and construction. In some French forms of canister shot irregularly-shaped pieces of iron and old nails were, till lately, employed under the name of 'mitraille,' for service at close quarters.

Case-grape.—An order issued a short time ago decided that no more grape shot, as hitherto arranged, are to be employed in the British service. The shot, instead, are placed in cylinders, and the projectile generally is constructed on the same principle as the case shot just described. The construction of the cylinder is altered, there being inside, in addition to the outer thin iron case, a loose circular iron plate at the base, and a thick inner iron

FIG. 4.

Case Grape.

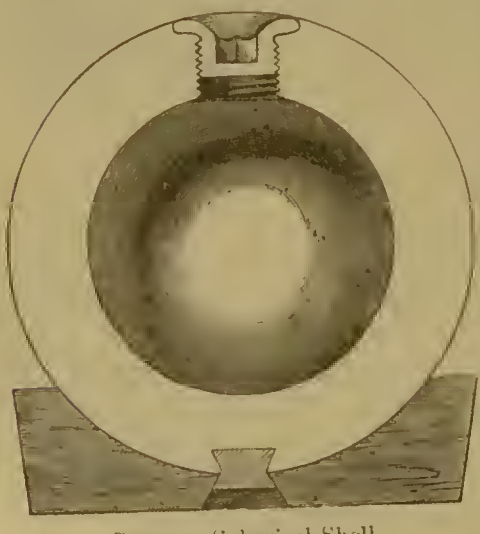
FIG. 5.



Section of Grape Case.

cylinder, divided into three parts, so that there may be substance enough to contain the heavy iron balls within, and at the same time as little impediment as possible to the rending of the cylinder by the discharge shock (figs. 4 and 5). The shot are not so large as grape shot, but are larger than those hitherto placed in case or canister. This projectile is stated to have superior destructive power and more endurance than either case or grape, and at the same time to be capable of doing the duty of either. One of these case-grape projectiles, weighing 92 lbs. without the bursting charge, contains 113 shot, each weighing nearly half a pound, the weight of the case being 37 lbs.

FIG. 6.



Common Spherical Shell.

Shells. — Any hollow iron projectile adapted for enclosing a quantity of gunpowder, or other explosive material, and designed to be burst into pieces on this material being exploded, is called a 'shell' (fig. 6). Shells have been projected from guns of various forms, from mortars, howitzers, guns of position, &c.

They may be thrown by the hand; in the latter case they are called *grenades*.

The bursting charge is introduced into the interior through a circular opening in the shell. When the shell is prepared for use, the opening is filled by a tubular plug, called a 'fuze.' Ordinary fuzes contain a composition, which, being ignited by the flame emitted by the combustion of the gunpowder on the discharge of the gun, burns for a certain time and then ignites the bursting charge within the shell. The length of time, during which the fuze-composition shall burn before igniting the bursting charge, is capable of being regulated; and thus the distance to which the shell shall travel before being burst can also be regulated by the gunner. Other fuzes contain arrangements for igniting the bursting charge when the shell strikes an object. These are called percussion fuzes. Formerly the bursting tubes were made of wood, now they are made of metal; these metal fuzes are not unfrequent sources of wounds when shells burst among bodies of troops. The walls of the common shells employed with field artillery burst into from twelve to about forty fragments of various weights and sizes. These fragments are scattered in all directions, radiating from the centre of the explosive force by which they have been torn asunder, and are thus calculated to inflict a number of wounds among men in the immediate vicinity of the exploded shell.[11] The weight of a 32-pounder common shell is 23 lbs. 4 ozs.; the bursting charge consists of 1 lb. of gunpowder.

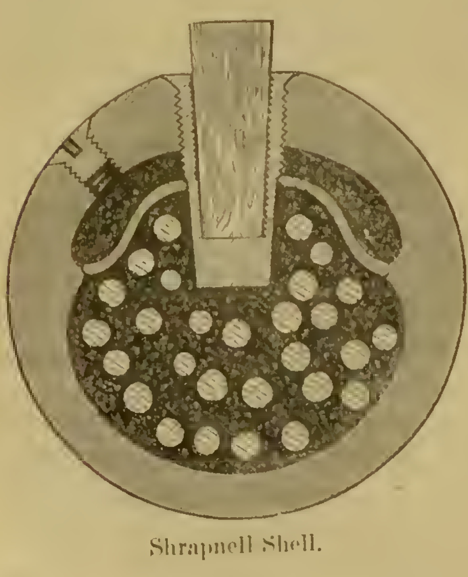
The smallest shell fired from a modern rifled gun is one of 7 lbs. containing a bursting charge of 7 ozs. of powder. The 7-pounder rifled gun with which these shells are used is only 150 lbs. in weight, has a calibre of three inches, and fires a charge of 6 ozs. It was used in the recent Ashanti war, and also in the Abyssinian campaign, where *shrapnell* shells were fired from it with very deadly effect.

The field-piece most recently introduced into the British service, is a 16-pounder gun, and is supposed to be one of the most powerful guns of its kind existing. Batteries of these guns are supplied with common and shrapnell shell and case-shot. The weight of both the common and shrapnell shell is 16 lbs. The shrapnell contains 63 balls of 18 to the pound, and 56 balls of 84 to the pound. Experiments have shown that at 1,500 yards, a shell bursting at the head of a column of troops, would cause from 150 to 220 hits. The service charge is 3 lbs. and the projectile is made to leave the gun with such velocity, that the bullets and splinters have still very great onward velocity, and, therefore, striking force, when the shell is burst at the distance above named. Such rifled field guns are the most powerful weapons used in battle. Under favourable circumstances their fire will extend over a range of at least 4,000 yards, and at this great distance the fragments of the burst shell may be relied on for killing and disabling a certain number in a body of troops.

Hand grenades.—These projectiles do not differ in any essential particulars from the shells just described. The circumstance of their having been made about the size of a pomegranate, sufficiently small to be held and thrown by the hand, has led to their receiving a special name. They are now chiefly employed in sieges, when they are thrown from the parapets among bodies of troops making an assault, sometimes singly by hand, or from swivel guns, but often projected in numbers together from small mortars placed just behind the works of the spot under assault. In the year 1678, a company of soldiers was added to all the British regiments armed with these projectiles, and they were hence called 'grenadiers.' Each grenadier had a pouch of hand grenades in addition to his firelock. This mode of carrying and using grenades ceased as far back as the reign of Queen Anne. The weight of a 6-pounder hand grenade shell is 3 lbs. 13 ozs.; the weight of the shell empty being 3 lbs. 9 ozs.; of the bursting charge, 4 ozs.

Shrapnell shells were formerly sometimes called 'spherical case shot.' A shrapnell is a shell filled partly with gunpowder and partly with a number of hardened bullets of mixed sizes. It is fired direct from a gun, with a very heavy charge of powder to project it, while its own bursting charge of powder is so reduced in quantity as to be only just enough to break it asunder. The bullets are hardened by mixing a proportion of antimony with the lead. Shrapnell shells are arranged to burst while they still possess an immense horizontal velocity. This velocity is, as a matter of course, equally possessed by the bullets within the shells; and the bursting charge not being in quantity sufficient to scatter or turn them much aside, they pursue their onward course, after the shell is burst, with great force. They are thus calculated on meeting a body of troops to inflict a large number of severe wounds among them. Shells of this description get their name of 'shrapnell' from that of their inventor—General Shrapnell of the Royal Artillery.

Fig. 7.



Shrapnell Shell.

Diaphragm shrapnell shells. It occasionally happened with the ordinary shrapnell just described that it burst prematurely. This appeared to be owing to the powder becoming ignited, either by the effects of the bullets rubbing against each other, or against the interior of the shell, after it had been projected from the gun. To prevent this accident, Captain Boxer invented a shell

in which the bursting charge is separated from the charge of bullets, and this kind was afterwards adopted in the British service. The separation is effected by a curved plate of metal (fig. 7), in a similar way that the cavity of the chest is separated from that of the abdomen, and hence the name above given. The arrangement of the diaphragm shrapnell necessitates two openings, one for the insertion of the gunpowder, and one for the shot. The former is filled up, when the projectile is employed, by the bursting fuze; the other by a metal screw plug. The fragments of the shell and diaphragm join with the fuzes and shot in adding to the number of wounds that may be inflicted on troops when the projectile is exploded. The weight of a 32-pounder diaphragm shell is 28 lbs. 9 ozs.; the weight of the shell itself being 17 lbs. 8 ozs.; the metal shot, consisting of musket, carbine, pistol, and buck shot mixed, being 9 lbs. 8 ozs. with 8 ozs. of coal dust; the bursting charge being reduced to $2\frac{1}{2}$ ozs. In a common shell of the same size, the bursting charge, as before named, is 1 lb. of gunpowder.

Cylindro-conoidal shrapnell shell.—But the power of destruction has been still further increased in the most modern form of shrapnell shell (fig. 8). Its external appearance is that of an ordinary cylindro-conoidal shell. Inside the shell is a number of bullets, and the bursting charge of powder is placed behind them. The case of the shell is very thick behind the bursting charge, and there is an iron disc between this charge and the bullets. The front of the shell consists of an easily separable head, with a time-fuze at the apex, when ready for use. The fuze is ignited by the flash of the gun, and the fire communicated through a central tube with the chamber at the base containing the bursting charge. The shell always points apex forward in its flight, as an ordinary rifle bullet does, owing to a similar arrangement as regards the rifling of the gun. When the bursting charge explodes, the separable head is blown off, and the shot, in addition to the onward movement which they had in common with the whole shell, now receive the increased velocity which is impressed on them by the explosion of the powder behind them. The shells fired from rifled guns have on their external surfaces studs, or ailettes, which are made to run in the grooves of the gun. These studs, on the bursting of the shell, often become detached with sharp and rugged edges, and in warfare frequently

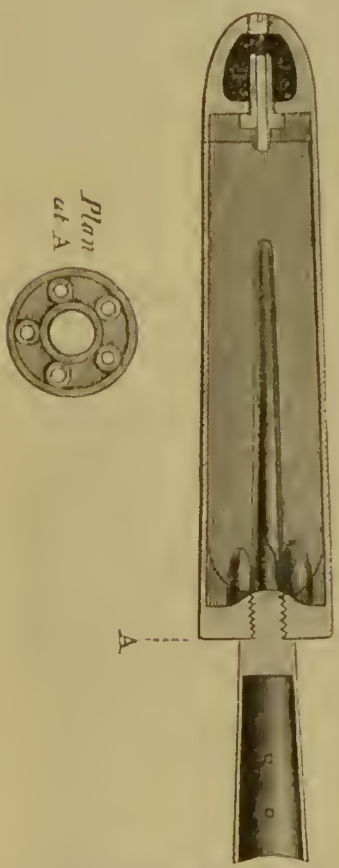
FIG. 8.

Section of Cylindro-conoidal Shrapnell Shell.

produce very severe wounds. The lead casing of some of the shells is also torn off in curled and twisted fragments, which further assist in inflicting injuries, often of a very severe kind.

Water shells.—These shells, invented by Professor Abel, are ordinary iron shells filled with water. Fixed to the base of the fuze is a metal 'burster,' made to contain compressed gun-cotton, and having a small compartment at its upper portion for a detonator of fulminate of mercury. When the fuze is screwed in, this burster occupies the centre of the shell. On the fuze being ignited the flame is communicated to the fulminate, and this in turn detonates the gun-cotton. An enormous force is instantaneously generated, which is communicated evenly in all directions by the water to the interior of the iron shell. The shell is broken up into fragments which are projected on every side. This shell, according to some published experiments, effected five times more hits against a target than when a shrapnell shell was used. One ounce of compressed gun-cotton in the burster broke a 16-pounder shell into 300 fragments, $\frac{1}{4}$ ounce into 121 fragments. The latter were considered to be the most suitable, as to size, for inflicting the greatest possible amount of injury.

Fig. 9.



Congreve Rocket Shell.

War rockets.—Rockets in warfare used to partake both of the nature of *shot* and of *shell*, according to the manner in which they were used. Their use as shell projectiles is now discontinued. Instead of being discharged by an explosive force from guns, they carry within themselves the means by which they are impelled onwards. A certain composition within the case of the rocket constitutes the source of the impelling force. When this composition is ignited, its expansive energy exerts a pressure forwards, while the pressure at the rear of the rocket is neutralised by the flame and gases escaping into the air through apertures provided for the purpose. This forward pressure lasts so long as the combustion continues, and causes a constantly accelerated motion of the projectile, until the resistance of the air counterbalances its progressive force.

The rods of military rockets were originally attached to their sides as in firework rockets, and great irregularities in their flight

resulted from this arrangement. Sir William Congreve placed the rod in a receptacle, called the choke or neck, fixed in the central axis of the rocket (fig. 9.), making provision at the same time by several openings around it, that the escape of the gas behind should not be interfered with when the composition was ignited. Notwithstanding this improved position of the rod, however, accidents frequently occurred in rocket practice.

Rockets are sometimes employed like carcasses for setting fire to buildings; but when used for inflicting wounds, they are directed against columns of troops in the same way as artillery. They are not, however, like guns, placed on heavy carriages, but are discharged out of portable troughs standing on tripods, so that they can be easily employed, if necessary, in mountainous places. When fired against cavalry, they not only produce wounds by direct collision, but lead to many accidental injuries by the panic and disorder which they create among the horses.

FIG. 10.

Section of Hale Rocket.

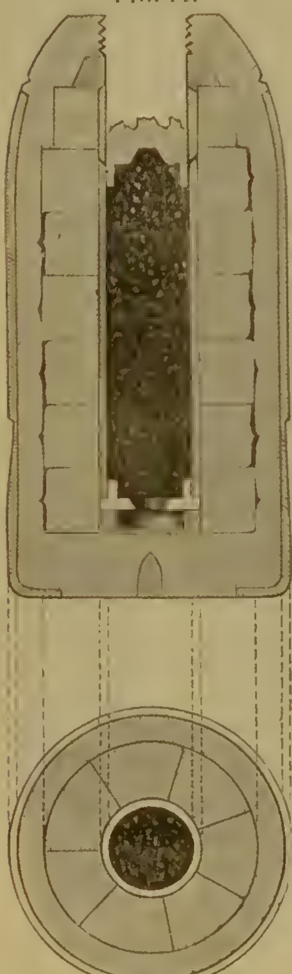
Hale's rockets.—These are rockets in which the openings for the escape of the gas turn obliquely to the long axis of the composition chamber, instead of being in the same line with it (fig. 10). The direction in which the gas is caused to escape from the projectile imparts to it a rotatory motion round its long axis, corresponding with the spinning movement which is imparted to bullets by the rifling of fire-arms, and thus gives steadiness to its flight, without the aid of the stick or tail with which ordinary rockets are constructed. The only rockets in use at present as war rockets in the British service are 24-pounder and 9-pounder rockets of the Hale pattern. They are only employed as shot rockets.

Carcasses.—These projectiles are like shells, so far as they are hollow cases of thick iron, but they are essentially different in their nature. They do not contain any explosive substance. A carcass is filled with a compact composition of a highly combustible nature. It is ignited at three openings in the shell by fuzes which pass down into the carcass composition. The flames that issue from the burning composition through these openings are intensely strong, and will set fire to any combustible substance within reach. Carcasses are chiefly intended to set fire to buildings in besieged places, combustible stores, shipping, &c. The light issuing from the flames is white in colour and very bright, so that carcasses are sometimes projected from mortars to light up positions at night from which attacks are expected, in the same way as light balls, and parachute or suspended lights. They were in frequent use at the siege of Sebastopol.

Armstrong gun projectiles.—In the latter end of the year 1854, Sir William Armstrong submitted to the Minister at War a proposal for a rifled gun on a new principle. This gun was subsequently adopted in the military service. Its peculiarities were the tough wrought iron of which it was made, the rifling of its bore with 34 small grooves, and the fact of its being a breech-loader.

The projectiles for this gun have afforded many points of interest to army surgeons, especially those known under the name of *segment shells*. They are in all cases made of cast iron, thinly coated with lead; and being of somewhat larger diameter than the bore of the gun, the lead, when the gun is fired, is crushed into the grooves, the necessary rotation given to the shell and windage prevented. The greatest recorded range obtained by the Armstrong projectiles has been $5\frac{1}{4}$ miles.

Fig. 11.



Breech-loading Segment Shell.

The segment projectiles—and this is their distinguishing feature—can be used with equal efficiency as a solid shot, as a shrapnell shell, as a percussion shell, or as a canister shot (fig. 11). Within the thin cast iron outer case, there are a certain number (42) of wedge-shaped pieces of iron; and these are built up in layers, like bricks in a brick wall, around a central cylindrical cavity. This cavity is designed to contain, when required, the bursting charge.

When used as a shot, this projectile requires no preparation; the arrangement of the wedge-shaped segments of iron is such, that their compactness is uninjured by external pressure. The effect is much the same as pressure on the crown of an arch. Such projectiles have been fired through a mass of oak timber, 9 feet in thickness, without fracture.

When used as a shell, and it is in this way that these projectiles are chiefly intended to be used, a bursting tube, with a concussion arrangement and time fuze are inserted. If the time fuze be well adjusted, the shell will burst within a few yards of the object; but if this should fail it will burst from the effects of the concussion arrangement when it strikes the object, or grazes the ground near it. Some of these shells were exploded in closed chambers where the pieces could be collected; and in one instance the following fragments were found:—106 pieces of cast iron, 99 pieces of lead, and 12 pieces of fuze,

in all 217 pieces. At another time, in experimenting on the effect of various methods of attaching the lead coating, some 12-pounder segment shells were burst in the same way, and the fragments collected. In one instance, 243 fragments: in a second, 292; in a third, 310 pieces resulted. The object of these experiments was to ascertain the method most effective in producing the separation of the projectile into the greatest number of fragments, and they will also serve to give some idea of the number of wounds which might possibly result from the explosion of a single Armstrong shell among a body of troops.

When required to act as 'canister' on an enemy close to the gun, the time fuze is so arranged that the shell bursts at the instant of quitting the gun. The projectile, equally in this instance, bursts into a shower of pieces, each of which has a forward velocity nearly equal to that of the shell at the moment of fracture.

While describing the number of fragments into which some of the Armstrong projectiles are capable of being broken, it may be well to refer to the number of wounds which the guns used in the field-batteries of horse-artillery, 9-pounders, are estimated to be capable of producing. The estimate, as drawn from experiments at artillery practice, is that, under the most favourable circumstances, a 9-pounder field-gun is capable of inflicting twenty serious wounds per round in a body of troops up to a distance of 1,500 yards, and that five such rounds can be fired in two minutes, thus giving a total of 100 in that time. The wounds are caused, some by bullets, if shrapnell is used, some by segments, if segment shell is employed; others by fragments of the iron case enclosing these shot or segments. It need hardly be mentioned that this full number of wounds can scarcely ever be produced on a field of action, where difficulties are usually met with in getting a clear view of the objects aimed at, in laying guns with precision, and where other impediments interfere with such results as can be obtained on artillery practice grounds.

Whitworth projectiles. — The main difference between the Whitworth and all other systems of rifled guns is, that the weapons are rifled by surfaces, and not by grooves, so that none of the force of the gunpowder is expended in changing the shape of the projectile by jamming it into the grooves. The form of the shot is such that the least possible friction occurs during its passage through the gun, and afterwards through the air, whence its initial velocity and length of flight are usually greater than in the Armstrong projectile under corresponding circumstances. Whitworth 3-lb. bolts have been projected nearly 10,000 yards, or between 5 and 6 miles.

In Mr. Whitworth's method the barrel of the gun is rifled in a hexagonal, spiral form, and the projectiles are of the same hexagonal form externally that the bore of the gun is internally. Hence, neither the term 'balls,' nor that of 'cylindro-conoidal projectiles,'

is applicable to these projectiles, and they are usually spoken of, as before mentioned, as 'bolts.'

The bolts are made so as to fit the bores of the gun with the utmost mechanical exactness, but they taper both before and behind, so that the point of contact is only near the centre, and of the most limited extent consistent with provision against the chance of windage. They have not been regarded with much favour in the military service, on account of the difficulty of preserving their perfect coaptation under circumstances of exposure.

Mitraillers.—These are guns specially contrived for the purpose of discharging successive showers of comparatively small projectiles with great rapidity. As they stand upon their carriages they resemble the guns of light field-artillery; but as weapons, although not portable fire-arms, they belong essentially to rifled small-arms. A volley from a mitrailler in many respects resembles a discharge of grape or canister, whence the name of the gun—*mitraille*, grape; but the mitrailler is so contrived as not only to be capable of directing a more rapid fire, but also of securing greater precision of aim, within certain ranges, by preventing the scattering of the projectiles discharged by it, than can be attained with case shot and grape, discharged from field-guns. Moreover, there is no loss of aim from recoil with mitraillers, when once they have been put in position. As a machine, the mitrailler is generally lighter and easier to move, and requires fewer horses and men for its management than an ordinary field-gun, and considerably less men than for a corresponding number of rifles, as usually employed. It follows that less men are liable to be hit by an enemy in their management than would be in the management of a corresponding force of separate guns or rifles.

Many military men on their first introduction believed that mitraillers were destined to be largely employed in the field in all future wars; but the experience of the Franco-German war of 1870 tended to shake that conviction. Although it may be quite true, as the advocates of mitraillers state, that within rifle ranges mitraillers are capable of inflicting a greater number of severe and fatal wounds among bodies of troops than any other military engine which has yet been contrived; still there exists the fact, that field guns firing shrapnell shells or case shot are far more destructive than mitraillers at distances beyond rifle range, and that, therefore, batteries of mitraillers are liable to be destroyed by field guns at distances at which they are unable to do any execution in return. But though it is doubtful whether mitraillers will offer such advantages as to induce combatants to use them in the future much in the open field, there seems to be no doubt that they may and will be largely employed in the defence of bridges, entrenchments, and fortresses. It, therefore, is still a matter of interest to surgeons to have some knowledge of the nature of these

new engines of war, and of their power in respect to the infliction of wounds.

Mitraillers are of various forms. Some have been formed on the principle of an ordinary revolver pistol; but the mitraillers most highly praised, consist of a number of rifled barrels united in one group, and connected at the breech with some mechanical contrivance, by means of which they can be either successively or simultaneously loaded and discharged in rapid succession. As regular weapons of war, they are said to be of American invention; but the compound guns, known under the name of 'infernal machines,' were framed on precisely similar principles, and had very similar objects in view. Two mitraillers, one a Belgian, the other an American mitrailler, have been chiefly adopted in Europe. One, the Belgian, known as the 'Montigny mitrailler,' from the name of its inventor, is furnished with 37 independent, externally hexagonal, barrels, fitted together and secured within a wrought iron outer-casing. The piece is fired by pulling a handle; the shots can be discharged in succession, slowly or rapidly, or they can be fired all at once in one second of time. The removal of the empty steel breech-plate which contained the cartridges, and the substitution of a full one, occupies five seconds. Thus a continuous fire at the rate of ten discharges a minute can be kept up, equal to a delivery of 370 rifle shots in a minute of time. The bullet used with this weapon is conical, about an inch in length, weighs 600 grains, and has a diameter of a little over half an inch (·534 in.). It is hardened, and has force enough at 60 yards from the gun to penetrate 30 half-inch elm planks. When all the 37 bullets are fired together, they scatter in so comparatively small a degree, that at 800 yards the shower is limited to a space of about 12 feet in width, by 10 feet in height, and at 1,000 yards the further separation is only about two feet. Many experimental trials were made with this weapon at Woolwich and Shoeburyness, but defects were found which prevented its adoption in the British service, though it has found favour in some other countries.

It was known before the Franco-German war occurred that the French had a large number of 'mitrailleuses,' as they were called in France, in batteries of eight mitrailleuses each, as part of their regular war armament. The details of their construction had been kept a secret, but they were known to be adaptations of the Belgian 'Montigny mitrailler,' which had been placed in the hands of a special committee for development, and it was understood that the French improvements consisted more in alteration of the ammunition and rifling than in the general mechanical construction. A battery of these mitrailleuses was stated to be capable of discharging 1,500 shots in five minutes to a distance of 1,200 yards and upwards. Notwithstanding that

there must be limits to the periods over which such rapid firing of projectiles can extend, owing to the heating of the weapons from which they are discharged, the expenditure of ammunition, and other circumstances, it was evident that the other nations of Europe would not permit any one Power to retain such a weapon without obtaining weapons of a similar kind themselves. In England, however, very little active interest appeared to be taken in the subject until about the time of the commencement of the Franco-German war, although it might well be imagined that the possession of arms of this description would be of great importance to a State whose number of defenders is comparatively small—each mitrailler by its mechanical construction being equivalent in power and endurance to a large number of individual riflemen. Now, however, England, like other countries, includes mitraillers among its weapons of war.

Gatling mitrailler.—The Gatling mitrailler, or Gatling battery, was invented by Mr. Gatling in 1862. In 1866, the United States Government adopted this gun as part of their armament. It was exhibited, and attracted a good deal of notice, in the Paris Exhibibition of 1867, and has since been tried, with others, in all the principal countries of Europe. It was, some time ago, adopted as part of the Russian armament. This is the mitrailler which has been adopted by the War Department of the British army.

The Gatling mitrailler has ten barrels. It differs from the Montigny mitrailler, inasmuch as its barrels and their locks revolve together, while in the Montigny the barrels are fixed, and their locks only move. It also differs from it in not being able to fire volleys, but only single shots in one and the same line; these, however, can be discharged with great rapidity. From its arrangement it does not heat so rapidly as the Montigny and French mitrailleuses, so that rapid firing can be maintained longer with it. It has also other mechanical advantages, which need not be mentioned here.

Three sizes of Gatling guns have been made, the largest throwing a projectile about half a pound in weight. The projectiles discharged by it are either solid shot, simple shells, or shrapnell. The Gatling gun that has been adopted as the British service weapon, is, however, a small-sized one, weighing a little over 3 cwt. or 7 cwt. with its carriage. The bore of each of its rifle barrels is 0·42 inch. The lead bullet used with it weighs from 375 to 380 grains; the charge of powder is 80 grains. Each Gatling mitrailler is capable of firing from 200 to 280 shots a minute, according to the manner in which it is served. A battery of 6 Gatling mitraillers, according to the trials made with it in this country, will have a hitting and wounding power at ranges of from 200 to 1,000 yards, amongst broken infantry on uneven ground of 900 a minute, against a close column of infantry of 1,200 men a minute. Up to 1,400 yards this

gun was found to be more effective in destructive power, considered numerically, than field guns throwing case or shells; beyond that distance, it ceases to maintain the superiority.

So far as surgeons are concerned in the treatment of wounds inflicted by mitraillers, their introduction, like that of single breechloading arms, is calculated chiefly to lead to greater difficulties in field-hospital administration. The question arises how far the surgical care and attention necessary for the increased number who appear likely to be wounded within very short periods of time when these weapons are employed can be adequately provided.

Other projectile machines employed for inflicting wounds.

Fougasses.—Fougasses are small subterraneous mines, constructed on various plans, but all on the same principles, for the defence of places on land. A certain amount of explosive material, in an appropriate case, is concealed a short distance below the surface of the ground, and such arrangements are made that the weight of a person walking over the spot suffices to cause the material to be exploded, and to effect the forcible projection of fragments of the case, or of stones placed over it, so as to wound troops that are advancing to an attack. The Russians at Sebastopol employed water-tight boxes containing between 30 and 40 pounds of powder, and the ignition was caused by the action of sulphuric acid upon a mixture of chlorate of potash, sulphur, and some other ingredients. The acid was contained in a glass tube concealed from sight, and the ignition was effected on the tube being crushed by the tread of a soldier. Sometimes a series of percussion shells are employed in a similar manner. Fougasses were largely employed in the defence of places during the war of the rebellion in the United States, but they appear to have been usually designated 'torpedoes.' In Europe, the name 'torpedoes' is generally restricted to the explosive machines placed in water, and designed for blowing up ships, and for purposes of coast defence. They are similar to fougasses in their nature and principles of action, but vary greatly in form and construction.

CHAPTER V.

PORTABLE FIRE-ARMS AND THEIR PROJECTILES.

Early history.—The first portable fire-arms, 'hand-cannon,' and 'hand-guns,' were not invented until after the larger kinds of gun, or cannon. The hand-cannon was merely a small cannon carried

by two men, and was fired from a rest fixed in the ground. The hand-gun was an improved hand-cannon, the tube being of greater length, and cast in brass. The tube was fixed on a straight stock of wood about three feet in length, and, like the cannon, was fired by a lighted match applied by the hand to a touch-hole at the end of the tube. The projectiles used with it were probably, like those of the first cannon, made occasionally of stone, as well as of iron and lead.

The hand-gun was next improved by the introduction of a trigger, to cause the burning match to be brought quickly, and with precision, into contact with the powder in the pan. This contrivance was borrowed from the trigger used with the cross-bow, and these improved hand-guns took the same name, 'arquebus,'[12] as had previously been applied to the kind of cross-bow which was fitted with a 'prodd,' or a tube for the discharge of small stones and bullets, before the invention of gunpowder. The yeomen of the guard, when first formed in the year 1485, were armed one-half with bows and arrows, the other half with arquebuses. The arquebus was thus the 'matchlock,' such as we still see it in use among some Eastern people.

The earliest English writer on injuries resulting from fire-arms is Thomas Gale. He was contemporary with Ambrose Paré, the earliest writer of note on the same subject in France. Gale published his 'Treatise of Woundes made with Gonneshot,' in 1563. In his work he mentions that he served in the army, under Henry VIII. against France, in 1544. He probably remained with it till the end of the war in 1546. He also refers to his service with the English forces which assisted Philip II. of Spain, in defeating the French at St. Quentin, in 1557. At these periods the greater part of the British infantry were still armed with bows and arrows, halberds, and pikes; only a small portion were armed with arquebuses.

About the year 1544, the musket, a Spanish invention, was first introduced into England. The musket was much longer and heavier than the hand-gun, or arquebus, so that, when discharged, it had to be supported on a staff, fitted with a forked rest at the top, and with a ferule at the bottom, to help in planting it in the ground. The muskets were matchlock fire-arms. It is to be inferred from Gale's writings[13] that, in his time, stones were still in use as shot, instead of leaden bullets, or pellets,[14] as Gale and the early English writers call them, with some of the above-named fire-arms.

'Snaphaunces,' which were portable arms discharged by the spark from a flint and steel, 'Firelocks,' were invented to take the place of matchlocks in the time of Queen Elizabeth. The 'fusil,' a flintlock fire-arm of about the same length and calibre as the musket, but considerably less in weight, was first made use of in England about the time of Charles II. Three of the regiments, still

known as fusiliers in the British army, were raised during this and the succeeding reign.[15]

It is quite evident, from a study of the fire-arms of early times, and of the projectiles employed with them, down to the time of the introduction of firelocks, that not only were the arms themselves roughly made and very unevenly bored, but that very little, if any, attempt was made to prevent windage by making the projectiles fit the guns closely. Accuracy of aim was consequently unattainable. The force impressed on the projectile chiefly depended on the quantity of gunpowder used.

Muskets and their projectiles.—The observations embodied in Richard Wiseman's 'Treatise on Gunshot Wounds,' were chiefly made by this admirable surgeon during the civil strife which led to so many battles in England between the years 1642 and 1650. At this time the shot used with the fire-arms carried by the troops seem to have been of fixed weights and sizes. The common musket, still a matchlock, had bullets 10 to the pound, the arquebus 17 to the pound, the carbine, with a flintlock, 24 to the pound. Pistols were also in use with long barrels, and carrying shot about 20 to the pound.

The writer next to Wiseman of importance in England, on gunshot wounds, was the illustrious John Hunter. Sir E. Home, in his account of the life of his brother-in-law, John Hunter, mentions that he went with the army to Belle-Isle as a staff-surgeon, that he served, while the war continued, as senior surgeon on the staff, both in Belle-Isle and Portugal, till the year 1763; and that in that period he acquired his knowledge of gunshot wounds. Mr. Hunter himself mentions that it was at Belle-Isle, after the reduction of the place, where he first arranged his 'Treatise on the Blood, Inflammation, and Gunshot Wounds.'

The ammunition used by the troops at this time appears to have undergone no change, so far as the projectiles were concerned, excepting a certain amount of diminution in weight. The gunpowder and musket had been improved in various ways; the latter was lighter, and the flintlock was used universally instead of the matchlock. The infantry soldier was disencumbered of various articles of equipment which he had previously carried, and his arms were now confined to the smooth-bore musket of ·75 inch bore, weighing together with the bayonet a little over 12 lbs. The bullets were apparently of the same sizes as those in use at the beginning of the present century, viz.: some nominally 14½ to the pound, varying from 480 to 488 grains, with a diameter of ·695 inch; and others weighing about 574 grains, with a diameter of ·745 inch. The charge of gunpowder was six drachms.

Leaden bullets were made then and for many years afterwards,[16] by being cast in moulds; and either from minute air-bubble spaces, due to the fact of the lead being bulkier in the molten than

in the solid state, and of the exterior becoming first cooled, or from impurities in its substance, it scarcely ever happened that they were of the same density throughout. From this and various other causes, some of which will be noticed hereafter, not only were the bullets discharged from muskets very irregular in their flight, but their rate of velocity was comparatively low, and the distance to which they were capable of travelling very limited.

The same fire-arm and projectile continued in general use among the British troops, without any improvement of note, during the Peninsular campaigns from 1808 to 1814, in the campaign of 1815, during the American war between 1812 and 1814, and in the numerous battles in which British troops were engaged in the East Indies. The smooth-bore musket in use during this period, was the weapon commonly known among soldiers under the name of 'Brown Bess.' Some of the native infantry regiments in India are still armed with smooth-bore muskets, but of a smaller bore (·656 inch), and smooth-bore carbines are still in use elsewhere. The 'Brown Bess' was the infantry musket of the period during which Guthrie, Hennen, Thompson, and many of the most eminent writers on the subject of gunshot injuries, practised and wrote.

In the year 1839, the flintlocks of the common muskets of the British army were altered into percussion locks. No difference was made at this time, either in the projectile or in the charge of powder.

In 1842, a new percussion musket was adopted. The change effected had reference chiefly to the manufacture of the weapon, which was now 'sighted' for 150 yards. The charge of powder was reduced from 6 to 4½ drachms. The size and weight of the bullets remained the same as they were in the beginning of the century.

Double-shotted muskets.—It was an accident of constant occurrence, when smooth-bore weapons were in use, for two or more charges to be fired off at once, owing to the pieces not having been fired previously, from carelessness or nervousness on the part of soldiers, but double-shotting of muskets was also ordered by military regulations under particular circumstances. According to the French official reports of the Crimean war, quoted by Dr. Chenu, each infantry soldier in the field was furnished with ten spare bullets, carried loose, in addition to his 54 rounds of cartridges. The loose bullets were ordered to be employed in certain cases of fire at short distances, one of them being used with each discharge, for the purpose of doubling the bullet of the cartridge.

Rifled muskets and their projectiles.—The invention of rifling fire-arms dates from a period of at least two hundred years ago, but it was not then turned to practical account in military service. There was considerable difficulty and much loss of time in loading the early kinds of rifled weapons, and these were, no doubt, the

causes which prevented their adoption for military purposes. It was only at the commencement of the present century that a rifled musket was placed as a weapon in the hands of British troops. In the year 1800, the 95th regiment, since become the Rifle Brigade, was armed with a rifle, known by the name of 'Baker's rifle.' This weapon was fitted with seven slightly twisted grooves, and it is stated could only be loaded with great difficulty. The projectile was a simple spherical leaden ball, and its weight 20 to the pound. In 1836 a two-grooved rifle, called the 'Brunswick rifle,' was issued to the same regiment instead of the Baker rifle. The two grooves made one turn in the length of the barrel. The bullet, a round one, was provided, as shown in the illustration (fig. 12), with a projecting belt, which had to be placed in the termination of the two grooves, at the mouth of the musket, in the act of loading. The weight of the bullet was 557 grains, its diameter $\frac{7}{10}$ths of an inch, the charge of powder 2½ drachms. The aim with this rifle was said to be accurate up to about 400 yards.

Fig. 12.

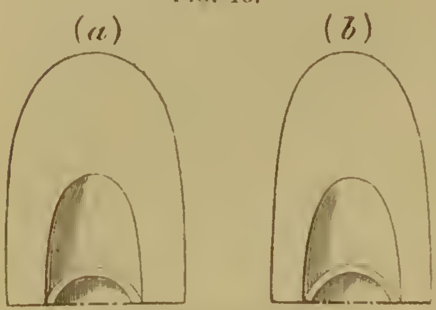
Brunswick Rifle, Bullet, and Muzzle.

The imperfection and comparative inefficiency of the 7-grooved rifle previously in use may be readily understood, when it is mentioned that in loading it the soldier had to drive down the bullet, which was a little larger than the bore of the rifle, by means of a mallet. Only one quarter of a turn could be given to the grooves in this rifle, owing to the danger of stripping the ball while forcing the projecting ribs between the grooves of the barrel into its surface. With the belted ball of the 2-grooved rifle the labour of driving in the ball by a mallet was got rid of, and one whole turn was given to the rifling. No sooner was this change made than a soldier of the rifle corps was able to strike an object at 300 yards, more surely than he had been able to do previously at 150 yards.

Minié rifle.—In 1851, instead of the percussion smooth-bore musket, a rifled musket and special projectile, invented by Captain Minié, a French officer, was issued to a great part of the troops of the British army. The essential feature of the new bullet was the addition of an iron 'culot,' or cup, at its base. By this means the bullet in the act of discharge was expanded and forced into the grooves of the rifle. The gas evolved in the explosion of the gunpowder was thus entirely prevented from escaping by the side of the bullet, and, at the same time, a longer range and greater accuracy of flight were ensured. The bullet used with the English Minié rifle was a very large one; it was 680 grains in weight, and its diameter was ·69 inch. The form (fig. 13) was at

first (*a*) conoidal, but was subsequently changed to (*b*) cylindro-conoidal. The charge of powder was two drachms and a half. The weapon was sighted for ranges of from 100 to 1,000 yards, and its point blank range was 177 yards. This was the weapon with which a great part of the British troops was armed that landed in the Crimea in 1854, and which was used by them at the battles of Alma and Inkerman. In consequence of the iron cup being occasionally driven through the bullet, leaving the latter a cylinder of lead inside the fire-arm, a box-wood plug was substituted for it, and to give additional ease in loading, the diameter was reduced from ·690 to ·675 inch.

Fig. 13.



Minié Rifle Bullet.

Enfield rifle.—In the year 1855, while the Russian war was in progress, a lighter and still more effective weapon was issued to the British army, instead of the Minié rifle of 1851, and the percussion muskets of 1842 which were still in use in some regiments. This was the Enfield rifle of ·577 inch bore. It has been the weapon in general use by the British infantry until lately, but several improvements were made in it after its introduction. The bullet first used with the Enfield rifle—the Pritchett bullet—was of a cylindro-conoidal form, with a hollow base without any cup or plug. Its weight was 530 grains, and its diameter ·568 inch. An iron cup was afterwards placed within the cavity of the base, similar to the cup in the Minié rifle bullet, and this was again changed for a boxwood plug. Small Enfield rifles were supplied to the Rifle Brigade and 60th Rifles, which were six inches shorter in the barrel than those issued to the troops in general. Steps were taken to ensure perfect purity of the lead used for the Enfield rifle bullet, because even slight impurity was found to affect its weight, evenness of consistence, and expansion. The bullets were pressed into shape by machinery from rods of lead, and there was now found to be scarcely any perceptible difference in the weight of one with another. These qualities gave them greatly increased efficiency as compared with bullets which had been cast in moulds.

A change in the shape of the Enfield bullet was made in 1859, during the war of the mutiny, in consequence of complaints coming from India of difficulties in loading the rifle. It was slightly decreased in diameter and increased in length. The diameter was fixed at ·55 inch, and the length 1·09 inch; the weight, with the plug, continued to be 530 grains. (Fig. 14).

Whitworth rifle bullets.—At the time of the Crimean war, Mr. Whitworth, the well-known mechanist, advocated the use of rifles

constructed on principles different from those of the Minié or Enfield rifles. The peculiarity of the Whitworth rifle, like the Whitworth gun before alluded to, consisted in obtaining the rifling by surfaces, not by grooves, as in the other systems. The interior of the barrel was hexagonal with one turn in 20 inches, and the bore was only ·45 inch diameter. The bullets were of two kinds: hexagonal, corresponding with the interior of the barrel; and cylindrical, with a hollow base, in which last case they were forced during their discharge to take the shape of the barrel. The cylindrical bullets had, therefore, to be of comparatively soft metal; but the hexagonal bullets, being independent of expansion, could have any degree of hardness imparted to them. This caused the Whitworth hexagonal projectile to differ from all other rifle projectiles in use at the time (fig. 15). These bullets were usually made of an alloy of lead and tin.

Fig. 14.

(a)

(a) Enfield Rifle Bullet, and (b) its base with the Boxwood Plug.

In 1864, three rifle regiments were armed with Whitworth rifles, and several other regiments were supplied with 100 Whitworth rifles each, to be tried in different climates. The reports were considered most satisfactory as to the power and accuracy in aim obtained with these rifles; but certain military objections were made to them, which need not be mentioned here. They are now no longer in use as military arms.

Breechloading fire-arms.—The fire-arms just referred to, both plain and rifled, were loaded at the muzzle; we come now to the change to breechloaders.

The first breechloading small arms used in the British service were carbines, issued to a few cavalry regiments in 1858. In 1862, the Government supplied a thousand breechloading *muskets* in small numbers to several regiments for practical trial. The fighting advantages of these weapons were their rapidity of fire and capacity for easy loading in any position of the soldier; among their chief disadvantages, at that time, were a difficulty in preventing an escape of gas at the breech, and the necessity for a special cartridge, such weapons not admitting of discharge with loose powder.

Fig. 15.

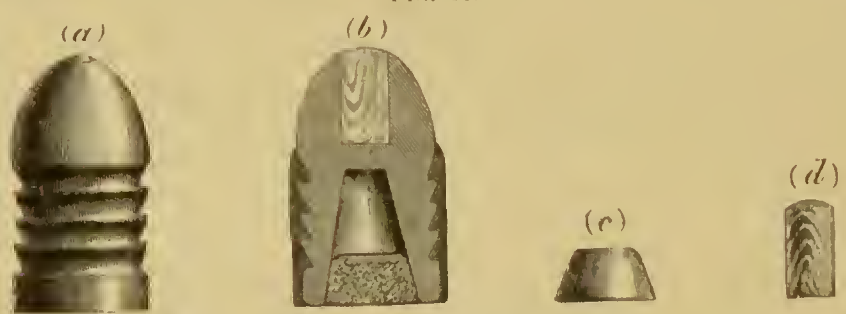
Whitworth's Hexagonal Bullet, and section of bore of rifle.

In the year 1864, a special committee was appointed to inquire into the desirability of adopting breechloading arms generally for Her Majesty's forces. The subject had already been extensively considered; and, although there were obvious advantages in the employment of breechloaders in war under certain circumstances, yet many practical objections

had been urged against their general adoption. These objections the committee was to examine and report upon. They did so, and, after some time, the committee presented their report, giving their opinion in favour of arming the infantry wholly with breechloading arms. Arming with breechloaders was then decided on; and the only question which remained was that of the mechanical form of breech-loading which should be adopted. The experience of the Prussian campaign of 1866 hastened the settlement of this point. It was found that, by a system devised by Mr. Snider, Enfield rifles could be economically converted into serviceable breechloaders, and this work of transformation was subsequently effected.

Snider converted Enfield rifle.—The projectile for these altered rifles was changed in some respects. The weight of the Snider bullet was 480 grains, complete with its plugs. It was 1·04 inch in length. Its hollow base carried a baked clay plug; it had four saw-shaped cannelures round the outer circumference near the base, which served to retain a thin coating of wax; and it also had a wooden plug in the head (fig. 16). The introduction

FIG. 16.



Boxer Ammunition for Snider converted Enfield rifle, (*a*) Elevation, (*b*) Section, (*c*) Clay Plug, (*d*) Wood Plug.

of the last-named plug afforded greater length to the projectile without adding greatly to its weight, at the same time that it disposed the weight of the lead away from the axis of rotation, after the manner of a fly-wheel. From twelve to eighteen shots can be fired in a minute with the Snider converted Enfield rifle; the latter, however, is the extreme rapidity of fire attainable. The bullet is no larger than the bore of the fire-arm; it is expanded by means of the hollow in its base, and of the baked clay plug. The clay plug took the place of the iron cup and boxwood plug, which were successively placed in the Minié and Enfield rifle bullets.

In March, 1869, it was settled that the wooden plug in the head of the bullet should be removed, the cavity in the apex, however, remaining, but closed by spinning the lead over it. This bullet has, therefore, both base and front hollowed out. This is the latest form of projectile used with the Enfield rifle (fig. 17.) It is said that this bullet has all the advantages of accuracy possessed by the old Enfield bullet, at the same time that it is superior

to it as a weapon of destruction; the wounds by this hollow-headed bullet being much more severe than those inflicted by a solid-headed bullet.

Former investigations had tended to show that the calibre, twist, and form of rifling of the Enfield rifle, were not the most favourable for accurate shooting; and it was, therefore, not unknown that the Enfield would, in time, have to give place to an altogether new breechloading weapon of smaller calibre, notwithstanding the great outlay which would be involved in the change. A reduction of size in the bullet was necessary, to enable the soldier to carry the increased quantity of ammunition which is required when breechloading arms are employed, and also to put the English on a footing with some other nations in this respect.

FIG. 17.

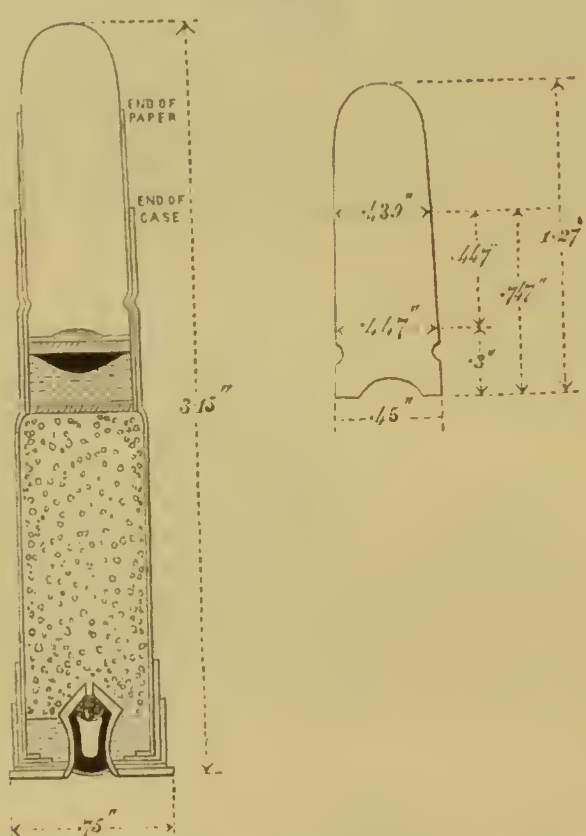
Enfield Rifle Bullet with hollow front and base.

Martini-Henry rifle.—In consequence of the attention directed to the improvement of rifled fire-arms, many means for increasing the power and accuracy of the converted Enfield rifles, especially at long ranges, had been made apparent. In order to get combined in one rifle all that had been discovered in these respects, the Government, in October, 1866, offered a prize for a new arm fulfilling certain conditions. The competition trials took place in 1868. Subsequently, a new weapon was formed out of two of the competing rifles, the Henry rifle and the Martini rifle, by uniting the barrel of the former to the breech of the latter. This is the rifle now known under the name of the 'Martini-Henry rifle.' The bullet used with this fire-arm is not made of pure lead like the Enfield, but of lead, hardened with tin, in the proportion of one pound of tin to twelve pounds of lead. It is cylindro-conoidal, solid, compressed, is 1·27 inch in length, and has a slight cavity at the base, which is ·450 inch in diameter. The bullet tapers upwards from the base to its smallest diameter (fig. 18). There is one shallow cannelure near the base into which the cartridge case is fastened. Its weight was at first 480 grains, but in 1875 it was reduced to 410 grains. The original charge of powder has also been lessened from 85 to 80 grains. There is a paper cap over the bullet lightly smeared with beeswax. A rapidity of fire without aim amounting to 25 shots in a minute has been attained with this weapon. As great an accuracy of aim appears to be obtained with it at a thousand yards as could be got with the Enfield at six hundred yards.

The greatest range of fire obtainable with the Martini-Henry rifle by elevating the rifle at a considerable angle (28° 15′), is 3,685

yards. The bullet starts from the muzzle of the rifle with a forward velocity of 1,443 feet in a second of time, and at a distance of 1,000 yards still preserves a velocity of about 600 feet in a second. It travels the 1,000 yards in less than three seconds. If brought into collision with an object close to the muzzle its striking force would be equivalent to 1,977 foot pounds;[17] at 500 yards it would strike with a force of 732 foot pounds; at 1,000 yards it would still possess energy equal to 378 foot pounds. Its point-blank range as regards infantry is between 200 and 300 yards. Its initial velocity of rotation is 744 revolutions in a second.

Fig. 18.



Section of Cartridge of Martini-Henry Rifle and Bullet with Measurements.

The penetrative power of the hardened lead bullet fired from the Martini-Henry rifle is very great, and this is a most important quality from a surgical point of view. When fired at 25 yards off, through half-inch elm planks placed one inch apart, the average penetration was through fourteen planks and a half; from the same distance the lead bullet of the Enfield rifle made an average penetration through only eight planks and a half. When fired against an iron plate one-eighth of an inch thick, the Martini-Henry bullet penetrated it at 500 yards, the Enfield not at 300 yards; when against an iron plate one-fourth of an inch thick, the

former penetrated it at 200 yards, the Enfield not at 150 yards. A wrought iron plate of one-third of an inch in thickness can be penetrated by it at 25 yards. Some comparative experiments were made on the carcase of a horse with the hardened and other bullets, and, according to the report of a veterinary surgeon who was present, the most severe fractures were produced by the Martini-Henry bullet. The Martini-Henry small-bore weapon now constitutes the armament of all the regiments of infantry in England and of nearly all on foreign service. Our native auxiliary forces in India are still armed with some of the weapons previously described, muskets, Enfield muzzleloading rifles, as well as breechloaders, but their armament with the approved small-bore rifle is probably only a question of time.

The following table, taken from Sergeant-Major Reid's description of the Martini-Henry rifle, shows the time of flight, *vis viva*, and penetrative power of the projectile for every 100 yards from the muzzle of the weapon up to 1,000 yards:—

Range	Time of flight	Vis viva	Energy per inch of circumference or penetration
At muzzle.	Seconds.	Foot pounds. 1,977	Foot pounds. 1,407
100 yards.	·2334	1,553	1,104
200 „	·4904	1,252	891
300 „	·7641	1,069	761
400 „	1·037	963	686
500 „	1·322	873	621
600 „	1·616	795	566
700 „	1·918	726	517
800 „	2·228	666	474
900 „	2·544	614	437
1,000 „	2·867	567	404

Pistols.—These comprehend the lightest kind of fire-arms employed in war, being made so that they can be held and fired by one hand only. The bullets discharged from them are the smallest-sized projectiles which are fired *singly* for military purposes.

The pistols in present use, or that have been recently in use, in different branches of the British service are of several kinds; some rifled, others smooth-bore; some muzzleloading, others breechloading. The rifled muzzleloading 'pistol carbine' is a heavier and longer arm than the common pistol, weighing 4 lbs. 11 ozs. and being 2 ft. 2 in. in length. The barrel is 10 inches long, and has a bore of ·577 inch. Its charge of powder is 2 drachms, and the arm is sighted up to 300 yards. It is principally in the hands of yeomanry cavalry. The rifled muzzleloading '10-inch cavalry pistol' weighs 3 lbs. 2 ozs. and is 1 ft. 3 in. in length. The barrel is of the

same length as the last, and its bore likewise ·577 inch. It is fired with 1 drachm of powder only, but is sighted up to 300 yards. The bullet used with these arms is in each instance 0·568 inch in diameter, 0·863 inch in length, and weighs 390 grains. The '10-inch pistol' is the pistol in general use in the cavalry regiments of the British army. A still lighter pistol, with the barrel only 8 inches in length, but having the same width of bore as the last, is used by some of the European cavalry in India.

The rifled breechloading pistols are all revolvers. They are of three kinds, distinguished by the name of the makers. The diameter of the barrel of the first, 'Adam's Service Revolver,' is 0·434 inch, and that of the bullet 0·455 inch. The length of the bullet is 0·765 inch, and its weight 225 grains. The diameter of the second, 'Colt's Revolver Pistol,' is 0·358 inch, and that of the bullet 0·38 inch. The length of the bullet is 0·612 inch, and its weight 135 grains. The third kind, 'Deane & Adams,' has a diameter of barrel of 0·434 inch, the diameter of the bullet being 0·457 inch. The length of the bullet is 0·63 inch, and its weight 214 grains. It is fired with 15 grains of powder. These arms are used by the police and constabulary, as well as by men of the Royal Navy and other services.

The smooth-bore pistols are of two kinds—the East India 8-inch pistol, used by the native cavalry of India, having a large bullet 0·6 inch in diameter, weighing 350 grains; and the 6-inch pistol, having a bullet 0·51 inch in diameter, weighing 205 grains. This last arm is chiefly used in England by the men of the coast guard. It will be seen from the foregoing statement that the weights and sizes of pistol bullets used in different parts of the British service vary very considerably, ranging from 135 to 390 grains in weight, and from 0·38 inch to 0·568 inch in diameter.

Buckshot.—These are the smallest bullets employed in the British service. Three kinds are used, two being used as ammunition for small arms, one being used as part of the contents of shells.

The buckshot used as small-arm ammunition are made wholly of lead. They are made up into cartridges for use with the Enfield rifle, and with all rifled weapons having barrels of a diameter of ·577 inch. Each cartridge contains 16 buckshot, the weight of the whole being 520 grains. The weights of individual buckshot vary from 30 to 33 grains each.

Buckshot of rather larger size are prepared for smooth-bore carbines. Each cartridge for this arm contains 7 buckshot, the weight of the whole being 378 grains. The several buckshot individually vary in weight from 52 to 56 grains. The same sized buckshot were also prepared for use with smooth-bore muskets. The ammunition for this purpose was made up in cartridges, each containing 12 buckshot, the weight of the whole being 648 grains.

The buckshot, prepared for use in the diaphragm shrapnell shells, are hardened by using a certain proportion of antimony with

the lead. Their weight, individually, is a little under a drachm, varying between 55 and 58 grains.

Large numbers of buckshot cartridges were manufactured for use against the Ashantees in the late war on the Gold Coast. They were of two kinds, one being for muzzleloading Enfield rifles, with which some of the native allies were armed, the other being for breechloading rifles in the hands of the British troops. Sixteen shot were enclosed in each cartridge.

Fire-arms and Projectiles of Foreign Armies.

The description given of the heavy guns and projectiles of the British service, renders unnecessary any description of the corresponding guns and projectiles of foreign armies. The differences that exist between them are chiefly in mechanical details that rather concern artillerists than surgeons; they have no influence upon the nature or character of the injuries produced by them.

The weights and some other features of the small projectiles used with the portable arms of foreign armies may, however, be referred to with advantage, more especially as, in case of England being engaged in a Continental war, these would be the sources of the greatest numbers of wounds which would come under the care of British surgeons.

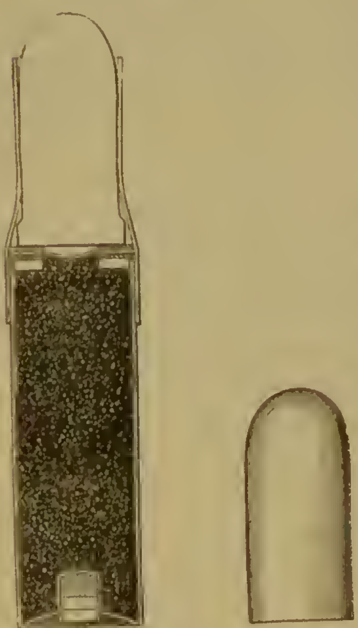
Nearly all the leading Powers have now introduced breechloading rifles with small bores for use in their armies. The weights of the bullets discharged from them vary between 310 and 410 grains. The initial velocity of the bullets, their trajectories, and the rapidity with which they can be discharged from their respective rifles, approximate so closely to each other, that, practically, from the surgeon's point of view, there does not appear to be any difference of importance between them.

The following table shows the approximate measurement of the middle diameters, the weights, and initial velocities of the rifle bullets in use in the principal armies of Europe compared with that of the Martini-Henry rifle.

Year when adopted	Army	Rifle	Bore of rifle	Weight of bullet	Initial velocity
			Inch.	Grains.	Feet.
1872	British .	Martini Henry	·450	480	1,362
1875	,,	,,	·450	410	1,443
1874	French .	Gras . .	·433	385	1,496
1871	German .	Mauser . .	·433	385	1,469
1871	Russian .	Berdan . .	·421	370	1,420
1867	Austrian .	Werndl . .	·421	315	1,400
1873	,,	,,	·421	370	1,476
1867	Bavarian .	Werder . .	·433	334	1,444
1869	,,	,,	·433	385	1,460
1870	Italian .	Vetterli .	·409	308	1,400

The projectiles of the Chassepôt rifle of the French army, now converted into the Gras rifle, and of the needle-gun of the Prussian army, have attracted so much attention in this country, and so many professional observations on the wounds inflicted by them, during the Franco-German war, have been published, that a short account of them will be useful for reference.

FIG. 19.

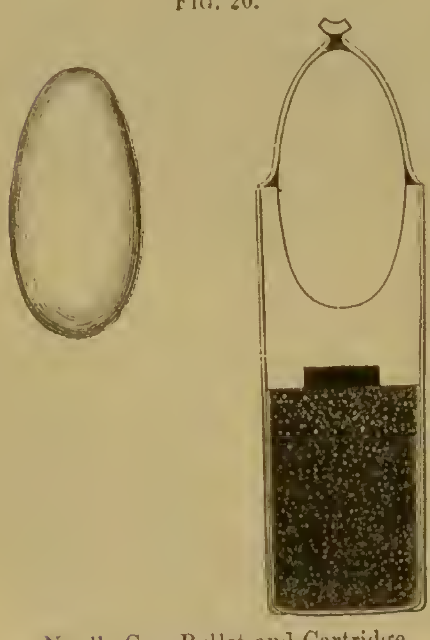


Chassepôt Bullet and Cartridge.

Chassepôt rifle (fig. 19).—This is a needle gun, the barrel of which has a calibre of 0·433 inch. The bullet is cylindro-conoidal, with a spherical apex; is one inch in length and nearly half an inch in its greatest breadth (·463); and is solid. It is made of lead, and its weight is given as 385 grains.[18] The base of the bullet is a little larger than the calibre of the gun, as shown in the sectional drawing of the bullet in the cartridge, so that it may be forced to take the grooves of the rifling. The charge of gunpowder was 85 grains. The initial velocity of the bullet was 1,476 feet in a second. The rifle was sighted for 1,000 metres—about 1,094 yards.

After the Franco-German war inquiries were instituted, and the necessity of making certain improvements in the Chassepôt rifle was established. These were eventually carried out on a system of conversion of the existing rifle proposed by Major Gras of the French artillery, and officially adopted in July, 1874. New rifles on the same system were also ordered. The changes were chiefly made in the breech mechanism of the rifle, and in the construction of the cartridge; the diameter and weight of the bullet were not altered. The bullet, however, is said to be harder: the hardness being obtained by compression of the lead instead of mixing it with an alloy.

FIG. 20.



Needle Gun Bullet and Cartridge.

The range varies from 2,500 to 3,000 metres. At 1,800 metres it has still force enough to be flattened against an iron target. The charge of gunpowder in the new cartridge weighs 81 grains.

Prussian needle-gun (fig. 20).—This rifle, the *Zündnadelgewehr*,

was invented as far back as 1836, by Herr von Dreyse. Four years later, orders were given to supply the light regiments of the Prussian infantry with it, and thus was introduced the first breechloading fire-arm ever employed in any army. This was the weapon used by the Prussians in the Danish war of 1864, in the war with Austria in 1866, and in the war with France in 1870–71.

The chief peculiarity of the needle-gun is the manner in which the bullet is supported within the barrel, and in which the rotation resulting from the rifling is impressed upon it. The bullet is held at its base in a *zündspiegel*—a papier-maché receptacle, or sabot, formed on the outside to fit the bore of the rifle, and adapted within for receiving the bullet, like an acorn in its cup. The *zündspiegel* also contains in a central position at its base the detonating composition. The charge of gunpowder is contained in a small paper bag behind it. When the trigger is pulled in firing, the steel needle is driven onward by a spring, and passes through the powder in the cartridge, and into the detonating composition through a central hole in the base of the papier-maché cup. The gunpowder is thus set fire to in front, and the evolved gas, acting upon the papier-maché cup, which is rather larger than the bore of the gun, and forcing it into the grooves of the rifle, causes it to rotate, and, with it, the bullet which it contains. As soon as the cup and bullet are out of the muzzle of the weapon, the bullet leaves the cup, and flies alone to its mark. From this description it may be understood that occasionally, when this rifle is fired close to a person, there will be a risk of the *zündspiegel* entering the body as well as the bullet, an accident which Professor Gurlt, of Berlin, stated in his description of the projectiles used by the opposing armies in the Danish war of 1864, that he had seen himself.[19]

The bullet of the needle-gun is ovoid in form, and slightly over one inch in length (1·08). When this rifle was first introduced, the bullet was 15·43 millimetres in its greatest width (·609 inch), but being found too heavy and deficient in speed, its breadth was reduced to 13·6 millimetres (or ·535 inch). Its weight was then 478 grains. These were the conditions in respect to size and weight of the bullet as it was used in the Danish war of 1864, and in the Bohemian war of 1866. Subsequently the weight was reduced from 478 to 324 grains, and the width to ·425 inch. The charge of powder remained 75 grains. The diminution in size of the bullet did not render any change in the fire-arm itself necessary; the small ball could still be fired out of the wide barrel by giving a proportionate amount of enlargement to the papier-maché cup in which it was carried. The elongated oval form of this bullet caused it to be very easily deflected on coming into contact with the rounded bones of the extremities, or other strong tissues presenting a convex outline, at all distances at which its force had been considerably diminished. The chief military disadvantages of the

weapon were its unnecessary weight, and its deficient range and power compared with some other modern rifles.

It has now been superseded by a rifle constructed on a principle originally devised by a gunsmith of Wurtemburg named Mauser. Its bullet is similar in weight to that of the new French rifle—viz. 385 grains—and it has the same diameter. Its range is stated to be about an English mile. The maximum rapidity of its fire is 26 shots in a minute, but any soldier is said to be capable of easily firing from 12 to 15 rounds in a minute with it.

Small shot.—The shot employed for sporting purposes are occasionally the cause of gunshot wounds in civil life, and when the shot is fired from a short distance these wounds present some specially hazardous features. Gunshot wounds also arise in civil life from the accidental or wilful discharge of shot from 'saloon pistols,' miniature cannon, and other toy weapons sold for purposes of amusement. A few years ago I procured for examination specimens of the shot of all sizes used for sporting purposes from one of the best London gunsmiths.[20] The numbers and marks by which the shot are distinguished from one another, and the numerical proportions of these shot to weight, are shown in the following tables. The shot consist of lead, to which a very small proportion of arsenic has been added :—

Small Shot.

Designation of shot	Number of separate shots to 60 grains	Designation of shot	Number of separate shots to 60 grains
No. 1 . . .	13	No. 8 . . .	70
,, 2 . . .	15	,, 9 . . .	100
,, 3 . . .	20	,, 10 . . .	180
,, 4 . . .	25	,, 11 . . .	200
,, 5 . . .	29	,, 12 . . .	257
,, 6 . . .	39	Dust . . .	334
,, 7 . . .	53		

The diameters of these shot gradually diminished from ·145 of an inch, that of No. 1 shot, to ·045, that of dust shot. The next table shows the weight and diameters of some of the larger kinds of small shot used for sporting purposes :—

Small Shot, Larger Sizes.

Designation of Shot	Number of Grains in each shot	Diameter of shot
A	9	·180
AA	10	·190
AAA	13	·200
B	6	·152
IB	$8\frac{3}{4}$	·160
IIB	10	·200
S.S.G.	$31\frac{1}{2}$	·300
S.G.	51	·325

Review of the general surgical effects of the successive changes in construction of military portable fire-arms and their projectiles.

The early kinds of portable fire-arms, or hand-guns, owing to their very primitive construction, were probably hardly so destructive as the cross-bows in use at that period; although from their novelty, together with the flame and loud report which accompanied their discharge, the moral effects may have been greater. Some of the cross-bows used in the English military service are recorded to have been capable of killing a man up to 60 yards at pointblank range, and up to 160 yards when duly elevated. The heavy cumbrous hand-gun with its wide and uneven bore, ill-fitting projectile, and ill-made powder, could scarcely have been used with such effect and precision. The changes subsequently made in the weapons, as well as in the quality of the gunpowder, gradually introduced a greater initial velocity, and, therefore, increased force, and a more extended range in the missiles discharged from them. The later improvements in smooth-bore fire-arms do not seem to have changed the severity of the wounds produced by them so much as they did the power of inflicting severe wounds over a wider area; but the number of wounds resulting from discharges of shot became greater, and the relative proportions of these wounds in respect to different degrees of gravity were altered. In comparatively early times, when once the greatest imperfections in hand-guns and the early smooth-bore muskets had been got rid of, if a soldier happened to be wounded at very short range, the wound might be as severe as one by the most improved weapon in use up to the time of the introduction of rifled muskets. But the greater number of wounds in early battles seem to have been inflicted at distances beyond the range at which such extreme effects could be produced. A large proportion of them were therefore of a comparatively slight nature; for the projectiles in use quickly lost their initial velocity on account of their imperfect shape and of other defects in them, and, on striking, were able to do little more than glance from the armour, which was worn for many years after fire-arms were introduced, or just to penetrate the surface when they entered the body. Hence probably the large number of recoveries reported in early surgical works on gunshot wounds, especially of recoveries after injuries of the trunk and head. The introduction of rifled weapons has led to results similar to those which followed improvements in smooth-bore fire-arms, but in a far greater ratio. The sustained energy of projectiles discharged from rifles, not interfered with by expansion of the fire-arms from heat or by the other disturbing influences which quickly lessened the *vis viva* of bullets projected from smooth-bore muskets, gave to combatants a vastly extended range over which a severe fire

could be maintained, and to military surgeons a proportionally increased number of severe wounds to treat.

The different effects produced by the old ill-constructed smoothbore weapons used by British troops a century or more ago as compared with those resulting from the improved rifles of modern times have been well illustrated in some recent campaigns in which British forces have been employed against tribes in a half-civilised condition. In the war on the Gold Coast the rifle was used on one side against very imperfect smooth-bores and badly made projectiles on the other. In the New Zealand war the relative condition of the opposing troops, so far as their fire-arms were concerned, was nearly the same as at the Gold Coast. So also in the Caffre war and in the China wars of 1857 and 1860. In the wars on the Gold Coast and in New Zealand, when the Ashantis or Maoris managed to creep by stealth through the bush, so as to be enabled to discharge their muskets at very close range, the wounds inflicted were sometimes of the severest kind, and in particular cases fatal; but the majority of those which were caused by the same weapons fired at greater distances were of a slight and comparatively trivial character. Out of 211 wounds inflicted in action on British troops in the Ashanti war of 1873–74, only 18 entailed fatal consequences, either in the field or subsequently.[21] On the other side the Ashantis are said to have lost heart because frequently they were hit at such long distances that they could not see the enemy who fired at them, and because, in the majority of instances when they were hit, the wounds proved to be fatal.

But the change to rifled fire-arms, and the altered forms and modes of motion given to their projectiles, have caused other changes in respect to gunshot wounds besides the distance at which they can be inflicted and their numerical frequency—changes which have materially influenced in many instances their very characters, and not a little their required treatment and its results. These changes will have to be separately considered hereafter. The most recent alteration of portable fire-arms, viz., their conversion into breechloading weapons, will probably not do much beyond what the previous changes had effected, so far as their wounding range is concerned. But the opportunity they afford of firing explosive and hardened bullets, which could not well be used with muzzleloading fire-arms, is a more important matter. Were explosive bullets to be employed in war, they would exert a fresh and serious influence on the characters of gunshot wounds. The use of hardened bullets may also modify them to a certain extent. The experience afforded by the use of the Prussian breechloading arm and the French Chassepôt, when compared with that gained from the use of other rifles, has not exhibited to surgeons any material change in the characters or features of the wounds inflicted. But the bullets used with the Prussian needle-gun and French

Chassepôt were ordinary lead bullets. The rapid, almost uninterrupted, discharge of projectiles that can be kept up for a certain time by breechloaders, and consequently the number of wounds produced among particular bodies of troops subjected to their fire, within given limits of time, has been the result which has hitherto chiefly attracted the attention of military surgeons, because of the increased difficulties which have followed in giving the necessary care and treatment to the wounded.

Speaking roughly, the change from the smooth-bore to rifled weapons gave ten times the range, with greatly increased precision of aim; while the change from muzzleloading to breechloading weapons, without any diminution in range or accuracy, has increased the capability for rapidity of fire tenfold. If machine guns continue to be employed in future wars, their capability for rapid fire may entail a further augmentation of the number of wounds inflicted in short periods of time, and still greater difficulties in surgical administration.

Projectiles of unusual kinds used with portable fire-arms.— In default of regular projectiles, and under circumstances of urgent need in warfare, anything capable of being used as a projectile with fire-arms may be expected to be employed for the purpose. In insurrections and civil wars especially, various things that are usually within easy reach, such as nails, toy marbles, small fragments of stone, gravel made up in packets, round metal buttons, and bits of glass, have been resorted to for inflicting wounds in addition to the projectiles in ordinary use. During the war of the Sepoy Mutiny in India in 1857, the Sepoys frequently used small sections of telegraph wire for want of better projectiles. The Maories also, during the last New Zealand war, occasionally used pieces of telegraph wire when out of regular bullets, as well as bits of iron rods that formed portions of fences. In one case of an extensively lacerated wound in an English soldier, a long rectangular piece of iron was found lodged in the wound. The Maori had fired this missile when at a short distance from the wounded man.

The projectiles used with fire-arms by nations in a half savage condition are usually very irregular in shape, and consist of very heterogeneous materials. The leaden bullets used by the Ashantis during the war of 1873–74, were never truly spherical in form, and varied greatly in respect of size and weight. They more commonly employed, especially in the latter period of the war, angular and sharp-edged slugs of iron and lead, and pieces of a dark siliceous ironstone. Sometimes pieces of native iron ore were fired from their muskets. The lead and iron slugs were cubes varying in dimensions from $\frac{1}{4}$th to $\frac{3}{8}$ths of an inch square, and appeared to have been cut from rectangular leaden or iron rods. Occasionally these slugs were hammered into a somewhat spherical

shape. The nodules of ironstone were of no regular form, and of all sizes that could be turned to account for charging a musket. Even beads were employed by the Ashantis when the other kinds of ammunition grew scarce.

The bullets used by the Kota Lama Malays against the British troops in January 1876, were made of tin, which is found plentifully in the Malay Peninsula; while lead, it is understood, has not been discovered there. They were fired as they were cast in the bullet-moulds, without being trimmed, so that they often had a projecting portion or tail, representing the tube through which the molten lead had been poured into the mould, and also a sharp-edged belt of tin with uneven adjustment of the two hemispheres of the bullet, owing to the two parts of the mould not having been properly closed. One peculiarity in these bullets was that in all of them some small fragments of earthenware, china, or pieces of glass, were imbedded. It is uncertain what the motives of the Malays were for making these additions to the tin. The specimens sent to the Museum at Netley by Surgeon-Major Collis vary in weight from 154 to 287 grains.

Occasionally shot, different from the ordinary forms, are employed among civilised people in warfare. It is probable that in most of the instances in which such eccentric missiles have been employed, they have been fired by individuals, either under a notion, generally a mistaken one, that they would prove more hurtful, or perhaps from simple wantonness, rather than under superior direction.

It has been mentioned by M. Scrive that double bullets, linked together by a spiral coil of wire, something after the manner of the chain shot which used to be employed for cutting rigging in naval warfare, were used by the Russians during the war in the Crimea. Specimens of these bullets were found about the works around Sebastopol, but no injuries received from them have been recorded, although after their discovery peculiarities in the characters of some wounds, which had not previously been satisfactorily accounted for, were supposed to have probably resulted from them. It seems likely, however, that, if discharged, the divergent forces impressed on the two bullets would be sufficiently great to break apart the connecting wire, which was of very slender diameter, before they came into contact with the troops against whom they were directed. Colonel Rennie presented to the Military Surgery Museum at Netley, a pair of bullets linked together by two loops of stronger wire than seems to have been employed in the spiral coils of the Russians. The loops are each an inch and a half long, so that the bullets are three inches apart when stretched out. Linked bullets of this kind were used by the matchlock men in Oude during the Indian Mutiny.

Count Bismarck, in a despatch dated Versailles, January 9,

1871, and addressed to the North German representatives at Foreign Courts, relative to the manner in which the French had carried on the war, stated as a fact that 'a cartridge has been found in the pockets of French prisoners, the ball of which is divided into sixteen segments, and loosely joined again. One of the many specimens of this sort of projectile, which is tantamount to chopped lead, has been sent to the Foreign Office at Berlin, and will there be submitted to the representatives of the Foreign Powers.' The idea that bullets are made more destructive by division into segments, or more injurious by furrowing their surfaces, is one that has frequently been held on occasions of war, and especially in civil conflicts.

It is mentioned in the 'British Official History of the Crimean War' (vol. ii., p. 262) that slugs were extensively used by the Russians on the occasion of the assault of the Redan on the 8th of May, and that they were made up for muskets like grape shot for cannon. They must have been somewhat similar to the buck-shot cartridges sent with the British troops to the Gold Coast for employment against the Ashantis.

Explosive bullets.—Hollow bullets charged with explosive materials, and prepared for acting on a small scale in the same manner as large shells, have been known to English officers for many years past. They have been designed both for sporting and for military purposes. Nearly fifty years have elapsed since Captain Norton invented his well-known rifle-shell. The celebrated 'Jacob' and other shell bullets followed. About the year 1862, after numerous trials, an explosive projectile for portable fire-arms, known as the Metford shell bullet, was adopted for use in the British army.

Incendiary and explosive bullets were also introduced within a few years of the same date in the armies of Austria, Prussia, Russia, Switzerland, Bavaria, and probably in those of other countries. The powerful explosive bullets invented by Herr Von Dreyse, and adapted for use with the breech-loading needle-gun of the Prussian army, particularly excited the attention of military surgeons.

In the year 1863 an incendiary bullet, filled with gunpowder and fitted with a percussion cap, was introduced into the Russian army. On striking against a hard substance the shock caused the inflammable material within to be ignited. This projectile was designed for blowing up ammunition waggons. In 1867 another description of explosive bullet for use with rifles and mitrailleuses was proposed for use to the Russian Government. This projectile contained a fulminating composition instead of gunpowder, and was so constructed that its contents would explode if it were brought into collision at high speed with a soft substance, such even as the skin of the human body. The igni-

tion of the contents of this bullet caused the projectile to burst into fragments, which did not happen with the incendiary bullet previously adopted.

The Russian Minister of War, General Milutine, considering that the use of these projectiles in war was of very doubtful advantage in respect to military exigencies, while their employment would necessarily involve a barbarous aggravation of the suffering of the wounded, proposed to renounce their employment in the Russian army. The Emperor Alexander accepted the views of the Minister, but convoked a conference in which all Governments were invited to take part by their representatives at St. Petersburg, in order to get a similar rule adopted in other armies. This proposal gave rise to the International Military Commission which held its first sitting on the 28th of October, 1868. The result of this commission was an agreement by the principal military powers of Europe to abstain from the use of all explosive projectiles less than 400 grammes in weight. The motives which induced the conclusions arrived at, and the text of the treaty on this subject, will be found in the Appendix.[22]

Notwithstanding the International agreement just referred to, there is great misgiving on the part of many as to the abandonment of explosive bullets in time of war. The Government of the United States has not joined the Convention, and the treaty is only obligatory upon the contracting parties when at war between themselves; it also ceases to be obligatory in case of a power, which has not joined the Convention, allying itself to either one or other of the belligerents. The English Government of the day was greatly blamed by the Press and by many military men for joining the treaty.[23] It was argued that England ought not to submit to the imposition of arbitrary rules restricting her mechanical skill, which she must rely on to counterbalance her numerical inferiority in troops and military implements of warfare; and it was further urged that whatever treaties might be made on such subjects, any struggle for self-preservation will certainly override them.

It may be useful, therefore, to describe briefly the construction and the peculiar qualities of these projectiles, and the influence these qualities are calculated to exert upon the characters of the wounds which the projectiles are intended to inflict. The description of one or two forms will suffice.

Construction of shell bullets.—There is very little change in the essential features of construction of any of the various shell bullets since they were first invented in 1822 by Captain Norton. The change which has been made in them depends rather on the general alteration of fire-arms from muzzleloaders to breechloaders; for this alteration enables them to be used to any extent without risk to the persons using them. When incendiary, or.

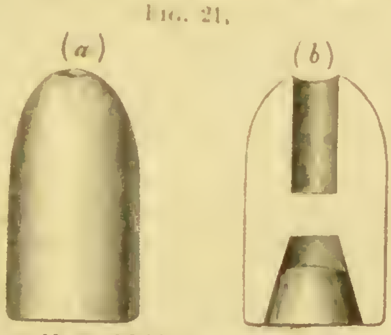
more particularly, fulminating bullets were used with muzzle-loading arms, a certain amount of risk in forcing the projectile down the bore of the fire-arm could not be got rid of. Now that the bullet has to be simply placed in a receptacle fitted to receive it at the breech of the fire-arm, this risk is removed.

The bullets invented by Captain Norton were of two kinds, one containing ordinary gunpowder, the other fulminating powder. In both kinds the bullet was somewhat elongated in form, rounded in front and behind, and it presented, on its lateral surfaces, projections adapted for being placed in the grooves of a rifle. They each contained a cylindrical cavity, about the third of the width of the bullet in diameter, and extending from the front nearly to the base of the projectile.

In Captain Norton's detonating bullet, the striking force, on the shell reaching its object, was obtained through the medium of a plug of wood inserted into the head of the bullet. In his incendiary bullet the explosion of the gunpowder, which was held in a small metal case within the cavity of the bullet, was effected by an ordinary percussion cap. General Jacob's rifle shell, and other similar projectiles, differed little from the explosive bullets just described excepting in external form.

The Metford explosive bullet, which was adopted in the British Service for use with the converted Enfield rifle, differed in some essential features from the bullets above described. The cavity containing the fulminating powder was stopped at the apex of the bullet by a plug of wax. At the base of the bullet (fig. 21) was placed a wooden plug. The effect of this arrangement was that in the passage of the bullet through the fire-arm the plug at the base so compressed the detonating powder and wax, that on the bullet meeting any obstacle in its flight, even a sheet of paper, the shock was sufficient to cause the explosion of the fulminate and the dispersion of the bullet in fragments. The length of the Metford bullet was 1·06 in., its diameter ·55 in.; its weight when empty was 525 grains, and when filled 582 grains.

Fig. 21.



(a) Metford Rifle explosive Bullet; (b) Section of Bullet empty.

Qualities of shell-bullets affecting wounds.—Surgically regarded, there is an essential difference between the larger kinds of shells and shell-bullets. The former are designed for bursting before reaching their object, and then inflicting wounds by the fragments into which they become broken: the latter are intended, first to penetrate the objects they are aimed at, and then to inflict further injury by their explosion.

It is evident, therefore, that on the explosion of a projectile of this latter description within a limb or cavity of the body, not only the forcible penetration of the projectile, but also the effects of its enlargement and distortion, if simply expanded and ruptured by the explosion, or of the violent dispersion of its fragments, if broken into pieces, as well as the distending force and the particular qualities of the gas and residuum evolved by its explosion, are all to be taken into account, when estimating its injurious effects on the human body.

CHAPTER VI.

ON LIQUID AND GASEOUS PROJECTILES.

Fluid projectiles.—Although substances in the fluid state are rarely employed with guns as projectiles, owing to the practical difficulties which spring from the want of sufficient cohesion among their particles, and the rapidity with which the particles of liquids are dispersed in their passage through the air, it is still proper to be remembered that they are fully capable of inflicting wounds when the necessary velocity is impressed upon them by fire-arms, and other circumstances are favourable. Water has been occasionally employed by soldiers on the Continent as one means of suicide. It is said to have been resorted to on several occasions in Prussia. The needle-gun being loaded in the ordinary way, a wad of mashed paper or rag is rammed down the barrel against the charge, and then water is poured in and secured in position by a cork. The head of the soldier is then placed opposite to the muzzle and the gun fired. The cork would probably suffice to kill under the circumstances. General destruction ensues from the immense projectile force of the column of water, and life is extinguished before the bullet reaches the victim. The idea seems to be that the bullet alone might perchance fail to inflict a mortal wound, or at any rate might fail to cause such extensive, and therefore such speedy and fatal destruction, as the column of water and bullet combined. It is well known that water is sometimes employed as a projectile, but at a further distance from the gun, in shooting humming and other small birds for purposes of natural history. Here the special qualities of the fluid, the little cohesive force of the particles, and their ready conversion into spray by the action of the air, are taken advantage of. Sufficient force is retained by the charge to knock over the bird, but this force is so distributed that neither the feathers nor the body of the animal are mutilated by its impact. In Professor's Abel's water-shell the water is not used as a projectile, but only for transmitting the disrupting force to the substance of the shell.

Liquid incendiary projectiles are occasionally employed, but when directed against persons the purpose is not so much to act as shot for inflicting wounds, as for inflicting injuries by burning. Ordinarily, in regular warfare they are employed with the object of setting fire to storehouses, ships, magazines, and other military buildings. The celebrated 'Greek Fire,' the use of which dates back to very early times, though very variously composed, seems always to have mainly consisted of coal tar, naphtha, and turpentine or petroleum, mixed with a certain amount of phosphorus. 'Greek fire' was used at the siege of Charleston in 1863, but its employment led to such representations respecting its barbarity, that the use of it was but little resorted to, if at all, during the remainder of the United States war.

Molten iron, poured into a shell specially constructed to receive it, known as Martin's shell from the name of the inventor, has been already alluded to. The shell is lined with a non-conducting coating of loam, to retain the iron in a liquid or semi-liquid state. The shell is so formed that on striking the object against which it is directed, the concussion breaks up the shell and scatters around the molten iron which was contained in it. Although, like other incendiary shells, designed for being fired against ships and buildings, the terrible nature of the wounds which would result in case of spurts of the red hot viscid iron striking men standing near the object against which the shell was broken, may be easily conceived.

Gaseous projectiles.—The injuries produced by the gases resulting from exploded gunpowder, independently of those which are caused by the solid substances which are set in motion by the explosion, are frequently considered under one only of the accidents which are liable to result from them, viz. burns. But many injuries in warfare, besides burns, local as well as general, have their origin in the source just named. Numerous serious lesions result from explosions, without any burning of the injured persons accompanying them; and in the cases where the flame of the explosion reaches the surface of the body, the scorching which it produces is usually complicated by other conditions, which materially influence the gravity of that particular injury and the effects of treatment. The most important of these conditions, especially in its general influence on the frame of a soldier, is that which results from the violence of the blow given by the exploded gunpowder acting as a projectile, or by the waves of air which have been driven onward by it.

When a volume of gas is suddenly evolved by the ignition of an explosive compound, it gives rise to that violent propulsive force, due to its elastic qualities and to the pressure to which those parts of the volume first evolved are subjected by the parts subsequently evolved, which is so well illustrated in the ordinary pro-

jection of a solid missile from a fire-arm. If not acting upon a missile prepared to be subjected to its effects, the force will be exerted upon the first opposing object met by the volume of gas, such as a person standing near; the amount and character of the force being determined by the volume and degree of compression of the gas, the rapidity of its evolution, the concentration of its action according to the manner in which it is directed, and the nearness of the object upon which it acts. In this way the gases derived from explosive compounds, from their striking men with concentrated force, become not unfrequent *direct* causes of injury in connection with fire-arms. If no solid objects be near at hand, the evolved gases may cause the surrounding atmosphere to become an *indirect* cause of similar injury, owing to the impulse they communicate to it, just as direct solid projectiles give rise to secondary, or indirect, projectiles by propulsion. The hurts thus produced are real 'wind contusions,' not mythical ones, like the wounds often attributed to 'vent de boulet.' They are met with under various circumstances in military practice. The volume of gas may be projected from fire-arms, from the bursting of shells, from explosions of gunpowder in cases and magazines, or from the discharge of mines, sunk shells, fongasses, or torpedoes, such as are frequently employed in siege operations. The amount of force which may, under particular circumstances, be developed by the gaseous agents under consideration, has been already referred to, when remarking upon the kinds and general qualities of the explosive compounds which are ordinarily employed for military purposes. The nature and characters of the injuries resulting from them will have to be described hereafter.

SECTION II.

ON THE CAUSES WHICH INFLUENCE THE NATURE, CHARACTERS, PROGRESS, AND ULTIMATE ISSUES OF GUNSHOT INJURIES.

Introductory remarks.—A gunshot injury is more or less modified in its primary characters and degree of gravity by

(A) Conditions appertaining to the projectile by which the injury is caused; and

(B) Conditions appertaining to the part or parts of the body injured.

The conditions (A) appertaining to the projectile are of two descriptions, viz.:—

1. Its inherent physical qualities, as: (*a*) its form: (*b*) dimensions; (*c*) volume; (*d*) weight; (*e*) component substance; and (*f*) density.

2. The accidental qualities impressed upon it by the fire-arm from which it is projected, as: (*a*) the velocity with which it is made to travel; and (*b*) its mode of rotation.

Two other qualities of bullets which have been supposed to affect the wounds inflicted by them may be noticed, viz., (*c*) heat developed during flight or at the moment of impact, and (*d*) a quality of poison.

The conditions (B) appertaining to the part injured are: (*a*) the angle of impact, or relative position of the part struck to the projectile striking it: (*b*) the site of injury; and (*c*) when penetration has occurred, the subsequent course of the projectile, and the depth to which it penetrates.

Lastly, the *subsequent stages* of a gunshot injury, its progress and ultimate issue, are influenced (C) by a variety of conditions independent of those already named and mostly extraneous to the injury itself; such as the state of health of the wounded man at the time of receiving the injury, the circumstances in which he is placed as regards prevention of aggravation of the injury during removal to hospital, and the opportunities there may be of giving proper care and treatment to him in hospital afterwards.

The circumstances by which the primary characters of gunshot

injuries, and their degrees of gravity, are liable to be modified, or have been supposed to be modified, will only be studied in the present section. They will be separately considered in the order in which I have already named them.

CHAPTER I.

(A.) ON THE CONDITIONS APPERTAINING TO THE PROJECTILES THEMSELVES BY WHICH THE GUNSHOT INJURIES ARE MODIFIED IN THEIR PRIMARY CHARACTERS AND DEGREES OF GRAVITY.

1. *Inherent Physical Qualities of Gunshot Projectiles.*

(*a*) **Shape of projectiles.**—As regards massive projectiles, differences in shape exert but little influence on the characters or the gravity of the injuries produced by them. Whether a gun shot be in the form of a spherical mass of iron, of a cylindro-conoidal shot, of a Whitworth bolt, or the missile consist of a shell before explosion, or a large fragment of shell of irregular outline, the effect on organised structures, other things being alike, will be the same. General crushing of the textures impinged upon will ensue, and the projectiles, whatever their shapes, will be equally destructive to life or limb from the mere bulk and weight of the masses of metal of which they are composed.

It is in the wounds produced by projectiles discharged from portable fire-arms that the effects of variation in shape are chiefly observed. The *forms* of musket bullets, more especially as regards the change from the spherical to the cylindro-ogival and cylindro-conoidal forms, present several questions of interest for the consideration of army surgeons. In discussing the subject, however, we must bear in mind that our experience is very limited as to the effects of round musket balls propelled with an amount of force approaching that which recent improvements in fire-arms have given to the rifle projectiles in common use over very extended ranges. The change, so far as form is concerned, from the spherical to the prolonged cylindro-conoidal ball, seems to derive its chief importance in surgery from the apex of the latter exerting more or less of the mechanical characteristics of a wedge when brought into collision at high speed with living structures, while the former acted upon them only as an obtuse body. From possessing this quality, the power of penetration of conoidal bullets, and together with it the power of splitting asunder hard structures when an opening is effected in them, are greater. Their wounding qualities are thus added to independently of those derived from the increased energy which is maintained by them during their flight. Sup-

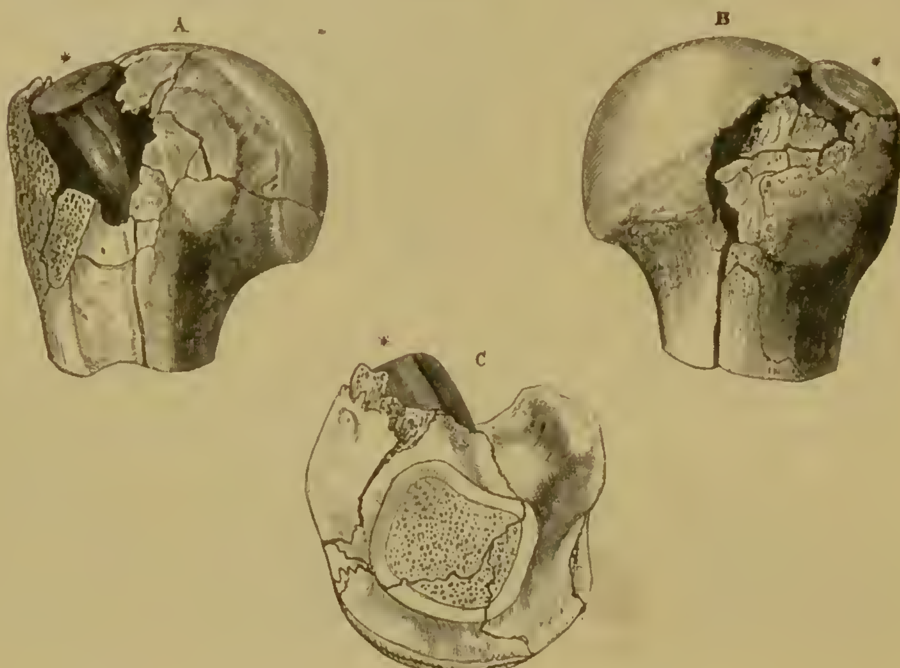
posing, therefore, one of the spherical musket bullets to strike a limb at 80 yards, and an elongated conoidal bullet of corresponding weight to strike a limb at 800 yards, at which distances their respective rates of velocity would be nearly similar, the injury from the elongated bullet may be expected to be considerably greater than that from the round bullet, solely on account of its conoidal shaped front. The wedge-like quality of the conoidal bullet is rendered particularly obvious on its being driven into the shafts of the long bones of the extremities. The solid osseous texture, of which the cylindrical portion of these bones is composed, is split up into fragments having mainly a direction parallel with the central cavity, while the fissures not unfrequently extend from the seat of injury to the terminations of the bones in the joints of which they form component parts. Such results were scarcely ever noticed from the impact of spherical balls. The shaft of a bone might be greatly comminuted if the projectile were fired close at hand, but the fragments were generally less elongated and narrow in form, and the long fissuring which is now so frequently witnessed did not usually occur. The broad-fronted bullet struck a larger area and gave a more smashing and stunning blow, with more lateral disturbance; the narrow-fronted bullet a more penetrating and dividing one.

The same difference of effect may be observed on comparing the injury produced on the apophysis of a bone by a conoidal with that produced by a spherical bullet. The splintering caused by the conoidal bullet will probably be found to extend to a considerable distance into the shaft, while not improbably the injury from a round ball will be limited to the immediate neighbourhood of the part struck by it. This difference obviously ought to exert an influence on the treatment of such an injury by resection, as regards the extent of bone to be removed. The following sketches (see figs. 22 and 23) of the heads of two humeri removed in consequence of wounds inflicted on two soldiers at the battle of Inkerman, one by a spherical, the other by a cylindro-conoidal bullet, well illustrate the relative effects just described. The two bullets happened to strike the same parts in the two bones, and with the same amount of force, as shown by the equal depth to which they penetrated; almost the only remaining difference between them, therefore, was the difference in their respective shapes. The preparations from which I was kindly permitted to take the drawings are in the museum of the Royal College of Surgeons of England.[1]

The greatly increased power of penetration which results from the conical shape of bullets, other things being equal, is exemplified in the objections which sportsmen generally have to using cylindro-conoidal rifle bullets when hunting wild animals of a dangerous character. Indian experience has tended to show that for such purposes round heavy blunt shot are preferable. The

object of sportsmen is to give a blow that shall hit so hard as to stun a savage animal, as they cannot always depend upon giving one which shall prove mortal; and they use a spherical ball in preference to a conoidal bullet on the same principle that a bullock may be felled by the back of an axe, the sharp edge of which, though it might penetrate more deeply, would fail to knock him over. A writer on elephant shooting in Ceylon some time ago remarked, that he got into dangerous scrapes by using some conical bullets with his rifle, though he had them made an ounce heavier than what he had previously used; the penetrating power was greatly increased, but the stopping power was lost. A belted 3-oz.

FIG. 22.



Sketches A and B show the condition of the head of a humerus which has been struck by a *conoidal* ball at the anterior aspect of the greater tuberosity. The bullet has entered, apex first, and is imbedded in the cancellous tissue, its base being on a level with the surface of the bone. Great splintering has followed, and the sketch C shows the fissured condition of the shaft at the part where the operation of resection has been performed. It is probable that these fissures extended some distance in the shaft below the line of resection.

spherical ball was like a sledge-hammer in its effects, and no animal could stand against it; but the pointed conical bullet went through like a spear-head, and was not so effective as smooth-bored guns with spherical balls. A deer shot through the belly by a conical bullet would be urged to swifter flight, and escape; a savage animal hit in the same way would be only rendered doubly savage by the pain.

Although the bullets employed for military uses have been prepared for the express purpose of destroying human beings, or, at least, of inflicting wounds upon them, very fortunately for the

mass of men exposed to be hit by them, the experiments to determine the best forms for insuring their possessing the greatest practicable amount of penetrative power have been chiefly made upon sheet-iron, solid oak timber, gabions filled with earth, and other such hard, inorganic substances. Had the experiments been made on substances possessing the qualities of the tegumentary covering and principal tissues of the human body, it is not improbable that a different form from either that of the spherical or the conoidal-topped front would have been adopted. Either a pointed conical or pyramidal apex would have increased the penetrative power so far as the human body is concerned. The

FIG. 23.

Sketches A and B show the condition of the head of a humerus which has been struck by a *spherical* ball in nearly the identical spot at which the specimen represented in Fig. 22 had been struck. The round ball, like the conoidal, has also entered to a distance corresponding with its own depth, its surface being on a level with that of the surrounding bone. Although the head of the bone has been greatly shattered, as shown in sketch A, the rending asunder, or splintering, is very limited, and the saw, in resecting the injured head, has passed through the shaft (see sketch C) without crossing a single fissure; and this, notwithstanding the operation has been performed somewhat nearer to the neck of the bone than in the preceding instance.

original Minié bullet terminated in an apex of the ogival form, a form which meets with very little resistance from the air during flight; and, although it never had the same power for opening a way through human tissues that a sharp-pointed conical or triangular front would have had, yet there can be little doubt that, so far as shape was concerned, its form gave it far greater power of penetration than the bullet of spherical form ever had, and more than the blunted conoidal form gave to the pattern which succeeded it.

Modern inventive ingenuity, however, has sufficiently devoted itself to the task of overcoming difficulties in respect to penetration, by increasing the velocity, and, therefore, the force of projectiles; the weapons from which they are discharged at the same time being so constructed as to insure the greatest number of these swift carriers of wounds and death being despatched on their fatal errands with sure and certain aim within the shortest limits of time. The penetrative power of a bullet of the cylindro-conoidal shape, as compared with that of the spherical bullets previously in use, is increased, moreover, by the prolonged form of the body of the projectile; one of the results of this alteration being a diminution in the diameter, and, consequently, a diminution in the resistance offered to its passage. The elongation in form of bullets entails other considerations as regards wounds which will be noticed presently, when the circumstances arising from the varying dimensions in length and breadth of the projectiles are studied.

Alterations in the shapes of bullets from accidental causes.—In studying the causes of the peculiar appearances, which will be hereafter noticed, of some bullet wounds, the alterations in shape impressed upon certain leaden bullets during their discharge, as well as by their occasional collision with hard objects after discharge, should not be omitted from recollection. These changes in form are effected in several ways. In the act of discharge from weapons, such rifle bullets as have hollow bases and plugs are distended by the action of the explosive gas; the plugs are driven forward within the bullets to varying distances, and generally become firmly impacted in their substance; while the bullets themselves are more or less increased in length. Their external surfaces are marked by impressions of the grooves, which they have been forced to enter during their transit through the bores of the rifles. Now and then the cap or plug is accidentally driven completely through such a bullet; but, in these cases, the prolonged cylinder of lead resulting from the accident is usually retained in the weapon. This happened not unfrequently when the iron cup was in use at the base of the Minié bullet. A bullet carried in a shoe, like the projectile of the Prussian needle-gun in use during the Franco-German war, meets with no alteration of form during discharge; it is not even marked externally by the twisted groove of the rifle. Solid bullets, like the Chassepôt and the Martini-Henry, take an impression of the grooves or surfaces along which they are forced, but are not changed in any other respect at the time they quit the muzzle of the rifle.

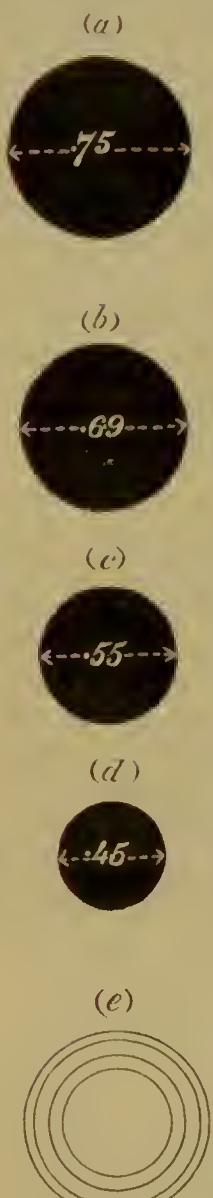
After discharge, bullets are liable to be altered in form either by striking against objects before they reach the individuals who may be aimed at, or by striking against objects carried on their persons, or by being brought into collision with bone after entering their bodies.[2]

Deviations in the form of bullets from impact against objects external to wounded soldiers, or from striking against hard objects carried on their persons, are as various as the objects themselves, and the angles of impact with them. Stones, gravel, or other hard substances on the ground in front of men, stone or brick walls, and other solid objects near which men happen to be standing, the iron barrels and wooden stocks of the fire-arms in their hands, the metal portions of their accoutrements, are some of the hard external objects by which bullets are usually deformed, and the appearances of the wounds inflicted by them influenced in consequence. Articles of uniform and clothing on the person, and even the toughest of the softer tissues within the body, have but little effect in changing the forms of bullets, though they will occasionally mark their surfaces when they are made of soft lead.

The general effect of the collision of a leaden bullet with a hard substance is to flatten it out to a greater or less extent, the outer edge of the depressed plate into which it becomes converted being the thinnest part. This thin edge is very often more or less torn, indented, and turned over upon itself. When a solid cylindro-conoidal rifle bullet strikes an iron target in a direct line, the base of the bullet is caused to form the centre of a circular disc. The disc is thickest in the centre, and gradually becomes thinner towards its circumference. The base of the bullet is generally so little interfered with by the collision, that, if it be marked with a number or stamp, especially when the number is on the crown of a hollow space at the base, it remains as legible after as it was before collision. The circumference of the disc is often so thin, in parts where it has not happened to become convoluted, as to present an edge which might readily cut into soft tissues. This may be taken as the type of all the changes in form which result from leaden bullets striking against plain surfaces as hard as iron or brass, whatever the angle at which they strike; but when they strike against convex surfaces, as those of gun barrels, or against uneven surfaces of stone or metal, the modifications are rendered infinite in variety. After bullets have struck and fractured bones within the body, we find them flattened, spread out, and twisted into every imaginable shape; or divided and broken up into a greater or less number of torn and distorted fragments of different sizes. These varieties depend in the first place on the softness of the metal, but also partly on the force and direction with which the bullets have come into collision with the outer surfaces of the bones, partly on the qualities of the particular bones struck, and the number and shapes of the fragments into which they had become separated. A certain amount of lead usually remains imbedded in the form of minute disconnected particles in the cancellated structure of the broken bone. The particular point of impact of a leaden bullet against a broken bone can often be de-

termined by observing the spot where granules of the lead may be seen to have been driven most deeply and thickly into the minute interstices of its substance.

FIG. 24.



Diagrams of the diameters and outlines of certain bullets. See description in text.

(*b*) **Dimensions of projectiles.**—The increased penetrating power derived from the diminished transverse diameters of the elongated bullets used with modern rifles as compared with the diameters of spherical bullets formerly fired from muskets, was referred to when the effects of 'shape' were considered. The variations in the length of these diameters of course lead to proportionate differences in the circumferential limits and in the wounding areas of the projectiles respectively concerned, supposing them to maintain a direct course. The actual differences in the destructive areas of the spherical bullet (*a*) which was used with the smooth-bore musket, and of the cylindro-conoidal bullets used with (*b*) the Minié (*c*), the Snider converted Enfield, and (*d*) the Martini-Henry rifles are shown in the accompanying diagrams (fig. 24.) The circumferential outlines of these bullets may be seen compared with one another at (*e*) in the same figure.

But other results affecting wounds spring from the altered dimensions of elongated cylindro-conoidal projectiles, which could not take place with the spherical bullets when they were in use. This influence more particularly requires notice, as it serves to explain, at least in some instances, the great laceration of the soft structures which is frequently met with in wounds from elongated projectiles.

In the spherical bullet there could be only one length of diameter in whatever direction the bullet might travel. If moving in a direct line, whatever face might be presented towards the object through which it was caused to pass, the passage opened by it would be invariably of the same width; if rotating on one of its axes, all its axes being equal, the same result would still follow.

But in the prolonged cylindro-conoidal bullets there is no longer only one length of diameter. In one direction, in the Martini-Henry for example, we have a length of diameter of rather more than an inch and a quarter (1·27″), in another a diameter of less than half an inch; so that the projectile presents one long axis, the one on which it ordinarily revolves during its flight, and a large number

of other axes, of various lengths, but all shorter than the dimensions of the long axis. If such a bullet passes through soft structures, and preserves its regular line of flight, the passage opened by it will be narrow, because it will correspond in diameter with the shortest of the short axes of the bullet, viz., with the measurement of its width, and not of its length. A narrow cylindro-conoidal bullet maintaining this line of flight may pass through an important joint, as has been shown by experiments, without rupturing the opposite surfaces composing the articulation, or may pass between two adjoining ribs, or other closely connected bones, without fracturing them, under circumstances where the bullets of larger diameters in former use could not have done so. But if, as will sometimes happen, owing to accidental disturbing causes during its discharge from the rifle, and the subsequent action of the air upon it, it gets a tendency to rotate on one of its shorter axes, or acquires a side to side movement during its flight, wabbling, as the gunsmiths call it; or if from contact with some hard substance just before entering the patient's body; or from coming into collision with bone, or other structures, after entering the body;—if from any of these causes it becomes deflected from its straight, directly linear course, then the dimensions of the passage made by it will not correspond with those of the shortest diameter of the bullet, but may be very considerably greater. The projectile may, under rare circumstances, even strike the surface of the body 'broadside on,' to use a sailor's phrase, instead of 'end on,' and the opening of entrance and the track through the flesh will then be caused to correspond in dimensions with the length, instead of with the breadth merely of the projectile. If, at the same time, the angle of impact be acute, so as to make the wound to some extent a rasing one, a very large and irregularly shaped wound will result, not unlike that which a small fragment of shell would inflict. These appearances may be presented when the part of the body struck is uncovered: they may be considerably aggravated if, in addition to the bullet, portions of clothing or accoutrements have been carried into the wound at the same time. When a cylindro-conoidal bullet, as it ordinarily flies, rotating on its long axis, is suddenly brought into direct opposition and collision with a body which does not yield instantly and become thrust aside by it, one of these things will occur:—

1. It may perforate the opposing substance, and pass on, retaining its original line of flight.

2. Its progress may be arrested, itself being simply crushed and flattened.

3. It may be separated into one or more portions which severally pursue their way in different directions: or

4. It may be caused to pursue its course in a new direction. In this last case, when it is deflected, its line of flight may be simply

altered in direction, its original movement of rotation and width of track being retained; or the rotation may be checked, and the projectile may prolong its passage sideways, that is, with its long axis at right angles to the line of its course; or the rotation on its long axis may be changed by the resistance it has met with into a partial rotation on one of its short axes, the bullet whirling round somewhat like the spoke of a wheel, when for the distance traversed a much wider wound, and very much more extensive mischief in the way of laceration of the adjoining tissues will be inflicted.

We used to have frequent evidence, when a cylindro-conoidal projectile lodged in a limb, of its having made a partial revolution of this kind, from the base of the bullet instead of its vertex presenting itself beneath the integument at the opposite side of the limb to that at which it entered. The apex of the bullet had been held temporarily at the spot where it had met with chief resistance, and this spot had formed a central point round which the projectile had made its partial revolution. It entered apex forwards, but it was excised base forwards.

This change in the course of rotation, and the more extended sphere of destruction which results as a consequence of it, may be especially expected to occur in hardened projectiles such as the mixed tin and lead projectiles; for these will be less likely to be flattened and completely stopped, or broken into fragments, on meeting with bone, than bullets of pure lead. Ordinarily we find a leaden cylindro-conoidal bullet which has been brought into direct forcible collision with one of the stronger bones of the body, more or less altered in form, especially at its apex, however much the bone also may have been crushed by the impact. The force of the stroke of the projectile has been partly expended in crushing itself, and partly in crushing the bone with which it has been brought into collision, and so further movement has been suddenly arrested.

(c) **Volume of projectiles.**—The volume, or extent in respect to the total amount of space occupied by one or other of the smaller kinds of projectiles, also exercises an influence on the results of wounds inflicted by them. A shot from a fowling-piece and even a small pistol bullet will pass through tissues, and sometimes lodge in important organs, cavities of the body, or other situations with comparative impunity, where the presence of a rifle bullet would almost certainly entail fatal results. A wound of a lung by the smaller projectile may heal in a manner which could scarcely occur had the wound been inflicted by the larger. The difference in volume between the several kinds of musket and rifle bullets is not, however, likely to make any material difference either in the characters or gravity of the wounds inflicted by them or in their effects in case of lodgement. Their differences in shape

and dimensions exert more influence than their differences in volume. The volume of the largest bullet used with the Brown Bess musket was equal to a little more than $\frac{1}{5}$th of a cubic inch. The volume of the Martini-Henry bullet weighing 480 grains is a little more than $\frac{1}{6}$th of a cubic inch; that of the bullet weighing 410 grains is $\frac{1}{7}$th of a cubic inch. It can rarely happen that these differences in the total amount of space occupied by the respective bullets will exert any material influence on the wounds inflicted by them, or in their effects on the tissues among which they may happen to be lying.

The measure of space of the projectiles employed with portable fire-arms is, however, so intimately associated with the measure of their weight that the import of the one can hardly be properly estimated without reference to the other. The quality of weight will be next considered.

(*d*) **Weight of projectiles.**—Differences in the weight of projectiles both large and small exert, to a certain extent, an influence on the characters of the wounds inflicted by them.

Weight of gunshot.—In the largest kind of shot, such as are projected from field-pieces or guns of position, the weight of metal is the quality which obviously exerts the most destructive power. So long as sufficient force remains accumulated in the masses of iron of which these missiles are composed to carry them forward, so long are their *volume and weight* the most important surgical ingredients in determining the characters and extent of the wounds inflicted by them.

A gunshot or large shell, if striking at all, must invariably inflict injury of a grave character. The weight of the artillery projectiles ordinarily employed is so great, that no diminution of velocity can enable them to strike a man with impunity. Although the propelling force be at its minimum, still the momentum is sufficient to cause serious damage. A gunshot is not like a bullet, the weight of which when there is very little velocity ceases to be of any account. A bullet, striking at the termination of its path when its velocity is all but expended, will not cause even a superficial bruise. But a gunshot, under like circumstances, though it may not have destructive power enough to carry away a part of the body struck by it, will certainly cause some severe injury; it may be only a simple fracture, a dislocation, or a superficial though extensive contusion, though more often the injury will be one attended with laceration of the structures opposed to it, and deep internal disorganisation. The weight of the projectile explains this destructive power. However small the velocity may be, if such a projectile be moved at all, the momentum, represented by the weight multiplied by the square of that velocity, is a force which no structures of the human body can resist. If the same sized shot were made of some denser

material than iron, if it were made of lead for example, its destructive power would be increased proportionally with the increased density, or nearly as 7 to 11, according to the different specific gravities of the two metals.

Weights of fragments of shells.—The weights of shell fragments vary from a few grains to several pounds. The velocity of shell fragments is so quickly expended, that, in the majority of instances, the well-known variableness in the characters and degrees of gravity of the wounds inflicted by them, is probably due more to the variations in their weight than to any other cause. The same remarks that have just been made with reference to gunshot are applicable, allowance being made for their relative weights in particular cases, to the heavy fragments of thick shells; while with regard to smaller fragments the same considerations arise in respect to differences of weight as occur in respect to rifle bullets and similar small projectiles.

Weights of rifle bullets.—With regard to small arm ammunition, however, the influence of weight seems to have been often dwelt upon beyond measure, more especially in regard to the comparative surgical effects produced by musket and rifle bullets of different weights. That the power of destruction of small projectiles is increased according as their weight is increased, form and other things being equal, especially when they are brought into collision with the hard structures of the body, is of course an obviously correct principle; but it is questionable whether there can be such differences in weight among the rifle projectiles which are likely to be issued for military use as to make the variations of any great practical importance to surgeons so far as the characters of the wounds inflicted by them are concerned. It is a matter of military necessity that a soldier shall carry a certain number of rounds of ammunition to render him efficient as a combatant, and he cannot carry the required number if the weight of each bullet exceeds from 400 to 600 grains. Now the differences in weight just mentioned have not been observed to exert any practical differences in the gravity of the wounds inflicted by bullets. It requires a considerable increase in *weight* to make a material impression as regards increase of destructive power compared with what is obtained by a slight increase of velocity. The *vis viva*, or moving energy, of an ounce bullet travelling at the rate of 50 yards per second would be measured by an integer of 2,500; a bullet weighing $1\frac{1}{4}$ ounce, practically a large addition in weight, moving at the same rate by one of 3,125; but if the velocity were only increased from 50 to 56 yards, a very slight addition in speed, the weight remaining one ounce only, the increase of destructive power which would be gained by adding one-fourth to the weight will be even exceeded.

In these smaller projectiles weight, therefore, considering the limits within which it must be restricted, is not a quality of

influence, such as it is in the larger kinds of projectiles. Some exceptionally heavy bullets were used by the Russians in the defence of Sebastopol, nearly one-third heavier than any employed by the troops opposed to them. There were two kinds employed by them, each of which is reported to have weighed 1 oz. 6 drs.[3] Had these bullets been propelled with equal velocity, they would obviously have inflicted more severe injuries on striking bones, more extensive and destructive effects in the soft structures of the body, and probably more nervous shock and other immediate disabling effects than the lighter Enfield bullets, the difference being due partly to their greater volume, but principally to their greater proportional weight. But the fact was, that either from being discharged from less perfect or less easily handled weapons, or from their velocity being more rapidly retarded owing to their greater size during their flight to the English works, these large bullets did not possess the same momentum, and consequently did not, as far as the means of comparison were afforded, effect greater injury than the Enfield bullets of less weight and size, in the fractures caused by them.

As to uncomplicated flesh wounds, the mere increased weight of the larger bullet would make but little difference under any circumstances in the gravity of the injury, or the time required for its cure. Owing to the larger size or volume of the bullet, the escape of foreign substances which the missile might happen to carry with it would even be facilitated; for there would be freer means of exit for the discharges from the surface of the track, and there would be less liability to some of the other complications which not unfrequently occur in the course of cure of wounds of very narrow dimensions.

Mr. Guthrie mentions, in his notes on the Peninsular campaigns, that having had a wide field for observation of the effects of the heavy British musket ball, 16 ($14\frac{1}{2}$?) to the pound, on the French wounded, he did not think them more mischievous in their results than the French musket balls, 20 to the pound, on the English soldiers; while the advantages of carrying a lighter musket, and a greater number of rounds of ammunition, were on the side of our adversaries.

It is understood that in warfare the object is not so much to destroy life as to disable antagonists, at least for the remainder of the campaign, and the smaller size has been supposed to be fully equal to this object by the British military authorities of late years. The weight of the old smooth-bore musket ball, that of Brown Bess, was in some larger kinds 574 grains, but ordinarily 483 grains, or $14\frac{1}{2}$ to the pound; and when the Minié rifle was substituted for that weapon, the weight of the ball was raised to 680 grains,[4] or about $11\frac{1}{3}$ to the pound. But in the Enfield muzzle-loading rifle projectile the weight was reduced again to 530

grains, 150 grains less than that of the Minié; while the bullet of the converted Enfield breech-loader was lowered still further, viz. to 480 grains. The first bullet used with the Martini-Henry rifle was kept at that weight, but it has since undergone a reduction of 70 grains, so that it now weighs 410 grains.

(*e*) **Component substance of projectiles.**—The materials of which projectiles are composed will influence to a certain extent the nature and characters of the wounds caused by them. This practically only refers to projectiles from small arms. If bullets of steel, or any similarly hard and coherent metal, should ever be found capable of being economically employed in fire-arms, many of the ordinary features of gunshot wounds as they at present exist will be materially changed. In proportion to the increase of hardness and cohesive force of the metal the greater will be the ease with which the brass plates and other parts of accoutrements, the strong bones of the extremities, the vault of the cranium, and any resisting structures will be perforated by it. Again, we shall have bullets which will not become softened at ordinary increases of temperature, broken and dispersed in fragments, subject to loss of substance, and capable of undergoing the various alterations in form which leaden bullets are apt to assume on coming into collision with certain external objects and hard parts of the body. If bullets could be made of such a brittle crystalline material as glass, other conditions of wounds would result. The dispersion of small fragments of irregular forms and sharp angles would be greater, and not only would the fragments be more numerous, but when lodged they would be more difficult of removal.

A comparatively soft, inelastic, but dense and cheap metal, such as lead, has hitherto, however, alone seemed to answer the general purposes and various objects sought for by combatants in these implements of injury. It was necessary that the metal should be a yielding one, in order that it might be forced along the muskets, or compressed into the grooves of the rifles; it had to be dense, so that it might present a considerable weight within a limited bulk; and it was required not to be costly so that projectiles might be provided in sufficient number for the purposes of war.

An alloy of tin and lead, as already mentioned, is now employed in the Martini-Henry projectiles, but the hardness is not so much increased in this mixture as to prevent the bullets from being readily pressed into shape, or from expanding when fired, and taking the grooves of the rifle. The surface of the Martini-Henry can be readily indented by the thumb nail, and nearly to the same depth as if it were a bullet of pure lead. Some projectiles have been tipped with iron, but they have never been used in regular warfare; neither have the hardened Martini-Henry projectiles, so that very little experience of the wounds inflicted by them has yet been gained.

(*f*) **Density of projectiles.**—The experiments showing the greatly increased power of penetration obtained by hardening the bullet of the Martini-Henry rifle with tin have already been noticed. This gain in penetrative power is due to relative hardness, not to any increase of density. As just mentioned, we have no experience of the action of such bullets on the several structures of living bodies. In the pursuit of wild and savage game, sportsmen have remarked that greater disabling wounds have been inflicted by mixing the lead of bullets with quicksilver than by mixing them with tin, owing to the superior specific gravity obtained by the former combination. An alloy of tin and lead undergoes expansion, and the density is less than that of pure lead in proportion to the amount of tin which enters into its composition; the alloy of mercury and lead undergoes contraction, and the density is considerably greater than that of lead alone. Other things being equal, increased density in the material of which projectiles are composed will give increased destructive power, but will not make much difference in the characters of the wounds inflicted by them, when compared with others of a like kind. Substances of very low degrees of density, such as plugs of tallow, light wood, cork, wads of paper, and others, will serve to inflict penetrating wounds in the softer structures of the body, having all the characters of wounds inflicted by denser projectiles, if sufficient velocity be impressed upon them. But the necessary force to accomplish this result can only be exerted within very limited distances, for the resistance of the air acting on such bodies as these rapidly retards their progress and destroys their force.

CHAPTER II.

CONTINUATION OF THE SUBJECT OF THE CONDITIONS APPERTAINING TO PROJECTILES BY WHICH GUNSHOT INJURIES ARE MODIFIED IN THEIR PRIMARY CHARACTERS AND DEGREES OF GRAVITY.

2. *Qualities impressed on Gunshot Projectiles by the Fire-arms from which they are Discharged.*

(*a*) **Velocity of projectiles.**—The rate of the velocity of progressive motion possessed by projectiles must always be a most important, and in many respects the most important ingredient for consideration in the study of the wounds produced by them. The rates of motion imparted to missiles by the fire-arms of early times were probably, from the imperfect construction of the weapons, defective quality of gunpowder, and other circumstances, as inferior to those of the musket in use a few years ago as the

velocity of those musket balls was, under the ordinary circumstances of warfare, when compared with that of the conoidal rifle bullets in present use under similar conditions. In a table showing the velocities of certain moving bodies, published a few years before the Crimean War, the common musket ball was set down as moving at an average rate of 850 miles per hour; the 2-grooved rifle ball, which was the arm at that time of the Rifle Brigade, at 1,000 miles; the 24-lb. cannon ball at 1,600 miles per hour. Statements such as these were of little practical value, for of course the true rate of motion of any particular projectile must be constantly varying during the whole range of its flight. The velocity diminishes from the moment the projectile quits the gun to the moment its course is finished. But, using the statement merely for purposes of comparison, it may be recalled to mind that at the time it was made the musket bullet could not be depended on to hit an object beyond 80 yards, the rifle bullet from 200 to 250 yards, while modern rifles are sighted to 1,000 yards and upwards.

Initial velocity.—The velocity at first starting, the *initial velocity*, of a bullet discharged from a smooth-bore weapon, such as the old musket, if the ball be well fitted (which practically seldom, if ever, happened in warfare), is really greater than the initial velocity of a bullet of like weight from a grooved rifle, propelled by a like charge of gunpowder. There is not the expenditure of power in the smooth-bore which there is in the rifle, in forcing the bullet to assume the form and follow the direction of the grooves. But when once the two kinds of projectile are free from their respective weapons, so great a resistance is offered by the atmosphere to the passage through it of the relatively large-fronted spherical projectile compared with what is offered to the prolonged cylindro-conoidal bullet, with its diminished frontage but equal mass, that the power of the round ball is altogether lost at a distance at which the conoidal bullet is in nearly as full force as when it quitted the muzzle of the rifle. The rifle bullet can never gain any increase of power over that which was first impressed upon it, but it maintains that power much longer than the round bullet, because the air has less retarding effect upon it. It is, therefore, evident that, in general, as regards wounds inflicted in warfare, the initial velocity is not of so much moment to surgeons as is the velocity which is preserved by the bullet at different distances in the course of its flight.

In particular cases, however, in which the wounds have been inflicted by bullets discharged from fire-arms within a limited number of yards, it is necessary to take into account the initial velocity of projectiles in order to explain the effects which are sometimes witnessed from their action. During the last war in New Zealand, a large proportion of the wounds inflicted on the British

troops were from smooth-bore projectiles fired at very short ranges, often from rifle-pits close at hand, and the destruction effected on the bones was great in proportion. Some surgeons, seeing the enormous amount of injury done by these round bullets in a few particular instances, were led to express an opinion that the general belief in conical bullets being so much more destructive than round bullets was founded on error. But in coming to this conclusion, they had omitted to take into account the great initial velocity possessed by bullets from smooth-bore weapons, and, as a necessary result, the great power of destruction belonging to them within very short ranges.

Influence of velocity on destructive power of bullets.—The increase in power of destruction from increased velocity is very great. Whatever might have been the power of destruction possessed by a bullet travelling at the rate of one of the old bullets from the smooth-bore musket after it had arrived at a distance of 70 or 80 yards from the firelock, another bullet of equal weight, but travelling at double the rate of speed at the same distance, would have had its power increased, not twice but fourfold. The rule is that if the velocity of a bullet be increased, its destructive power will be augmented proportionably with the square of the increase in velocity. If at any given distance a rifle bullet travel at ten times the rate of speed of a round bullet of the same weight, then, from that cause alone, without estimating the effect of its different shape or of any other peculiar qualities it may possess, its power of inflicting injury will be increased 100 times.

When the obtuse and comparatively soft round bullets were in general use, their power of penetrating the surface of the body altogether depended upon the degree of velocity which they possessed at the time of their being brought into collision with the persons struck by them. Their form was anything but favourable for penetration of the skin and subjacent tough and elastic tissues of the body. So also, on penetration being effected, the distance to which a projectile was carried was more completely dependent upon its velocity than is the distance to which modern bullets penetrate. A certain amount of velocity is of course essential for penetration in all bullets, but with the elongated cylindro-conoidal bullets the influence of great velocity for very long ranges is joined with better adaptation of form, with greater density and hardness from compression, and with a spinning rotation of the projectile, all favourable for penetration of tissues, or for turning aside structures of a long and moveable description. With the round bullets not only was great velocity necessary to give them the power of first penetration, but, from their obtuse form and the extent of area of their frontage, this velocity was more easily and more speedily retarded by the opposition of the tissues which they had to push before them, or by the resistance of the several layers

of yielding and elastic structures through which the projectiles had to make their passage. Even in passing through such soft tissues as the flesh of one of the extremities, the velocity became so retarded that, in consequence, the condition in which the tissues were left at the place through which the ball last passed differed considerably from the condition of the tissues through which it first effected its entrance. In penetrating bone, especially the spongy portions of bones, unless the rate of velocity was unusually high, the cancellated structure generally offered sufficient resistance not only to retard but to arrest altogether the progress of the projectile, and thus to lead to its lodgement. The elasticity of certain tissues, such as the skin, tendons, and ligaments, constantly led to similar results, when the velocity of the spherical projectile had been much reduced by the opposition it had met with from the structures through which it had had to pass before reaching them.

The increased velocity, or in other words, the greater force, of modern projectiles—for so far as surgeons are concerned the two terms are nearly equivalent—exhibits its effects in two directions; viz., locally, by the more complete destruction of the tissues in the track of the projectile; and constitutionally, by greater disturbance to the nerve force of the whole system. The component parts of that portion of the organised fabric through which a bullet, that will travel at the rate of eleven miles in a minute over a distance of 1,000 yards, cleaves its way, are inevitably deprived of their vitality. Instances are quoted by authors of gunshot wounds from musket balls having healed by simple adhesion, but it is difficult to understand how such cases could occur if the bullets by which the wounds were inflicted retained their original forms and average rates of velocity.

Hunter's remarks on some of the effects of velocity, and especially as to gunshot wounds healing by first intention.—John Hunter, after describing that in gunshot wounds parts of the solids surrounding the wound are deadened and have afterwards to be thrown off in the form of a slough, adds:—'This does not always take place equally in every gunshot wound, nor in every part of the same wound; and the difference commonly arises from the variety in the velocity of the body projected, for we find in many cases, where the ball has passed with little velocity, which is often the case with balls even at their entrance, but most commonly at the part last wounded by the ball, that the wounds are often healed by the first intention.'[5]

It is very difficult to explain this expression of John Hunter, that the velocity of bullets may be so diminished as to lead to the wounds inflicted by them healing by the first intention. I have never seen a bullet wound heal by the first intention myself, nor have any English surgeons of experience in such matters whom I

have consulted on the point—and I have consulted some of very large experience in almost every climate—seen such an occurrence. Not only have I never seen a musket shot wound heal by first intention, but I have never seen any part of one heal by this process, not the opening of exit any more than the track of the ball or the opening of entrance. I have seen musket wounds of simple character made by small projectiles with comparatively little force, heal with an extremely small amount of suppuration, the lint being merely moistened with the discharge at each dressing, and hardly any, if any, signs of inflammation being present; and I have also seen the edges of similar gunshot wounds, as happens with other contused wounds, occasionally agglutinated and held together for two or three days by a mixture of serum and blood dried together, but neither this limited amount of suppuration nor this temporary connection or covering would constitute ground for such an expression as Hunter uses, 'healing by the first intention.' In all the wounds I have just referred to, the healing was accomplished by granulation, or by the process of 'second intention.' I have never known a true scab form, with the healing process accomplished beneath it, in wounds made by bullets, as may happen in other wounds. The scars of penetrating gunshot wounds, however small they may be, always bear evidence that the cicatrisation has been attended by some amount of contraction, and this is a sufficient proof that granulations have been concerned in the healing process. Theoretically, if the death or extreme bruising of tissues in gunshot wounds were due only to the very high rates of velocity belonging to the projectiles by which such wounds were inflicted, the bruising diminishing as the velocity diminished, then a very low rate of velocity in a bullet might simply cause such a separation of tissues as would constitute it a lacerated wound without bruising or crushing, and, under such circumstances, one capable of healing by first intention. But practically an obtuse body, such as a musket bullet, especially one of the size, shape, and weight used with the old musket, could not force before it the elastic and resisting structures composing a fleshy part of the body, so as to effect a passage through them, without possessing such a degree of velocity as would inevitably contuse the tissues opened by it; and not only so, but such as would so injure some particles of its surface as would substantially convert them into the nature of a foreign substance, only to be got rid of by the process of suppuration, and to be replaced by the process of granulation. Moreover, the passage of a bullet through the soft tissues of the body is attended with many other circumstances which militate against primary healing, either by immediate union or by primary adhesion, besides those which depend upon the rate of velocity with which the passage is effected.[6]

I can only account for the expression of John Hunter which I

have quoted, by supposing that in this instance he depended upon others for information, and that this information was admitted by Hunter on the theoretical supposition of the events related being due to an extreme of diminished velocity, the means, indeed, by which he explains the occurrence of this kind of healing in the instances in which it was supposed to happen. In the particular cases of gunshot wounds quoted by John Hunter as having come under his own observation, no one instance is mentioned in which he himself saw the healing effected by first intention.

Influence of velocity in fractures of bones.—I mentioned the splitting and destructive effects of conical bullets on the shafts of the long bones of the extremities when referring to the peculiarities of their shape. But together with form, the amount of velocity, I need hardly observe, is an essential ingredient in estimating this result. The old round balls, from their lower rates of speed, on striking bones would simply be turned away from the direct line with some flattening of the surface, or even without being altered in form; or having perforated on one side, would remain in the cancellated structure, or would knock out a portion or portions of the shaft, generally without any such violent dispersion of them among the surrounding soft tissues as to interfere with the subsequent processes of repair, and without much splintering of the bone itself beyond the seat of fracture. Such mild effects as these are now rarely witnessed when the injuries are inflicted by rifle projectiles, probably never unless their speed has been so reduced by distance of flight, or by other accidental circumstances, as to place them on an equality with the old bullets in respect to their rate of velocity.

Velocity of indirect projectiles.—The rate of velocity of projectiles having irregular forms, and deriving their impulse from secondary, or internally applied forces, varies according to many circumstances, but is always less than would be that of direct projectiles of equal weights at corresponding distances from the point of discharge. The rapid alterations in their rates of velocity from the resistance of the air, together with the inconstant characters in respect to mass and shape of such projectiles as splinters of wood and iron, stones driven by shot from parapets, and fragments of shells, cause the wounds inflicted by them to differ from each other individually in their appearances no less than they differ in their general features as a class from those inflicted by rifle bullets.

The diminished force of the stroke of missiles of the secondary kind is not merely due to the fact that they receive their impulse secondhand, when the results of the primary impulse have been partly expended in the flight of the projectiles, but is also attributable to a further diminution in the impulsive force in consequence of the amount of resistance which has been offered to the

primary missiles by the secondary missiles in the very act of their displacement. Occasionally even simple fractures happen from indirect missiles; from direct, they are almost necessarily compound. From this cause, also, the constitutional shock in these injuries, unless they are exceedingly extensive owing to the size and weight of the indirect missiles to which they owe their origin, is, as a general rule, less than in direct gunshot wounds. In like manner, in common shells the opposition of the hollow iron sphere to the force of the bursting charge within causes the velocity of each fragment at starting to be comparatively low, while the shape of the portions into which such shells are usually rent asunder leads to this velocity being rapidly retarded during their flight through the air; remarkably so when compared with what is found to happen in the missiles of regular forms projected by direct explosion.

The velocity, and consequently the destructive force, of fragments of shells will, however, greatly depend upon the circumstances under which the shells are exploded. When they fall to the ground and are then exploded, the velocity imparted to the fragments is derived solely from the force of the bursting charge. This velocity is sufficient to give the iron fragments force enough to inflict very grave wounds within limited distances, but, owing to circumstances already referred to,—the flattened and irregular forms of the fragments, and consequent resistance of the air to their passage, together with the effects of their own weight, or, in other words, of the force of gravitation—the velocity is so rapidly retarded that the fragments only rise to comparatively moderate heights. When the shells burst while moving onwards with great progressive force, as already explained with shrapnel shells, then the fragments, for a short time, retain a great part of the velocity by which the entire shell was animated at the time it was broken asunder, and they strike with immense force. This velocity, however, is quickly retarded by causes before mentioned. When shells, on the other hand, burst at great heights in the air, then the fragments gain a constantly increasing rate of velocity according to the height from which they descend; or, in other words, according to the time they are subjected to the influence of gravitation. The velocity under such circumstances becomes so accelerated that the shell fragments strike with overpowering force, and cause proportionate destruction of all the tissues with which they may happen to be brought into collision.

Velocity of falling bullets which have been fired directly upwards, or nearly directly upwards.—Small rifle projectiles fired upwards into the air acquire so great a velocity in descending, that if they happen to fall on the head or upper part of the body of a person they usually produce immediately fatal results. From the suddenness of the event, the absence of warning, occasionally no weapon

or smoke being seen, no noise of discharge heard, such a mortal wound has a peculiarly appalling effect. During the siege of Sebastopol cases occurred where men were sitting in the trenches with their backs leaning against a parapet, protected from injury by direct shot, yet in this position were killed by bullets and grape shot falling from above. In one instance a bullet completely perforated the trunk of the soldier; it entered at the shoulder, traversed through the chest, abdomen, and pelvis, and then passed into the ground. The rifle from which it had been fired must have been pointed almost directly upwards, so that the shot at the time of striking the man was armed with the same destructive power as when it left the weapon. The final velocity of the bullet in this case would be the same as its initial velocity. In December, 1859, a case of the same nature occurred in the Governor-General's Camp in India, and attracted considerable notice. A native servant was cleaning his utensils after dinner, when, without a sound being heard, he fell dead. Surgeon Mackinnon, who was in medical charge of the Head-quarter Staff, was informed of the circumstance, and went to examine him. He found on the outside of the deltoid muscle of the left arm a small opening into the skin and out again, and just at the lower edge of the great pectoral muscle another small valve-like opening, such as might have been made by the introduction of a knife. Suspicion was excited that the man had been stabbed. On further examination a slight emphysematous crackling sensation was noticed just above the opening, and the surgeon, on introducing his little finger, which passed with some difficulty along the track of the wound over two ribs, came to a rough edge of bone. This was cut down upon with a scalpel, and a hole was found punched completely through a rib, a thin edge above and a thin edge below being left. The piece of bone had been carried through into the chest. The chest was afterwards opened, and wounds discovered through the lung, through both ventricles, through the diaphragm, a furrowed mark on the under surface of the liver, and finally a bullet was found lodged in the right iliacus muscle—the opposite side of the body to that at which it had entered. The bullet had evidently been fired upwards into the air by some one a long way off from the man whom it happened to hit in its fall.

Shot, the velocity of which is nearly expended, or 'spent shot.'—When the velocity of a direct projectile is diminished below a certain rate of movement, it is ordinarily spoken of as a *spent shot* or a *spent bullet*; and before leaving the subject of the effects of velocity impressed on projectiles, a few words are necessary with regard to the power of destruction possessed by the larger forms of these spent shot. Some of the effects of diminished velocity in the smaller forms of shot will be considered when making remarks upon the subject of 'Lodgement of bullets.'

After a spherical gunshot has ceased to pursue its course through the air, or to proceed by ricochet, it not unfrequently travels to a considerable distance, rolling along the surface of a level piece of ground. When its rate of movement is not much faster than that at which a man can walk easily, and when, to all appearance, the projectile might be stopped by the pressure of the foot as readily as a cricket-ball near the end of its course, it still possesses the power of inflicting serious injury if such an attempt be put in execution. This power will be easily understood by anyone who considers the amount of progressive force which must be inherent in the shot for it to overcome the weight of its own mass or the attraction of gravitation, as well as the resistance from friction to which it is exposed in passing over the rough ground on which it is rolling. This amount of progressive force or velocity, squared and multiplied by the mass of the shot, represents its destructive power. If a ball in this state is brought into collision with the foot of a person, such destruction usually ensues as to necessitate amputation. Should it impinge on other parts of the body, as in the instance of a man lying on the ground, it will not improbably cause mortal injury to internal organs; and so, also, though no longer having power enough to completely carry away a limb, it may cause comminuted fracture of bones and extensive contusions of the softer structures covering them. Occasionally a simple fracture will result from a spent shot, but such an accident is rare.[7]

Accidents used to occur not unfrequently from spent gunshot in the early periods of campaigns and sieges, before the soldiers who were unaccustomed to active service in the field had become acquainted with their qualities. Mr. Cole relates the case of a boy, whose thigh he had to amputate near the hip joint, for a laceration involving the femoral vessels from a 6-pounder shot, at the siege of Mooltan. In this instance the boy, who recovered, declared that the shot had not come to him, but that he had seen the shot rolling and thought it had stopped when he ran to pick it up. It is a proper precautionary measure for officers to warn young and inexperienced soldiers against the effects of spent shot, especially where spherical shot are used; nothing can be more deceptive than the apparent absence of danger in such shot, when they are seen rolling along the ground at a very moderate rate of motion. When the regiment I served with first took up its position on the right attack before Sebastopol, before the siege opened, several heavy round shot fell on different occasions within our lines. One of these dropped near where I was standing, and half-buried itself in a shallow, slanting depression, which its weight and the direction in which it had been projected caused it to make in the ground. While it lay at the end of the groove which it had thus pressed down for itself, it continued for some time turning round and round on its axis; even

after all forward movement appeared to have ceased, this movement of rotation continued. Several soldiers who had been attracted by the rushing noise of its fall had run towards the spot where the shot alighted, and one of these men was in the act of stooping down for the purpose of picking it up, when, fortunately for himself, he was pulled back by an older soldier, in time to prevent him from reaching it. Had he laid hold of the shot, he would no doubt have paid the penalty of the loss of his hand for his rashness. The force remaining in the ball was sufficiently evidenced to any reflecting observer, by the continued rotation of so weighty a mass. On the other hand, to mention an example of coolness resulting from familiarity with the qualities of such projectiles, at a later period of the siege, I happened to be near a French covering party, who were returning from the trenches, when the spurts of dust rising from the ground between us and the enemy's works attracted the attention of some of the men to a round shot, which was ricochetting in our direction. The ball ceased to bound at a moderate distance off, and then came rolling along up some rather sloping ground, which the covering party had just passed over. It soon reached the spot where we then were, rolled along through the party, and pursued its course for a considerable distance on in front of us. The rate of its movement was so slow that some of the men in front were easily put on their guard by the men in rear calling out to them, so that, one after another, they stepped on either side, making a lane as it were for the ball to pass through. There were plenty of jokes addressed to the shot by the soldiers as it passed among them, but there was no one who was not then fully alive to the necessity of making no attempt to interfere with its progress, though to the eye it seemed as if it could have been arrested in its course with the greatest ease.

M. Baudens has related a case which strikingly illustrates how extremely small an amount of progressive motion remaining in a heavy shot may suffice to enable it to inflict a fatal injury. A soldier in the Crimea, sleeping on the ground, was struck by a spent gunshot, and was instantly killed. He had been lying on his side, and the ball had rolled against him and dislocated his spine. Yet so little power of movement was there in the shot at the time, that it remained stationary with the man whom it had thus killed: it was found quietly lodged in the hood of the unfortunate fellow's great coat. In this instance, it is evident that, had the man been lying only a few feet further off, the projectile would not have had force enough to have reached him at all, but must have stopped spontaneously from the mere effect of its *vis viva* being completely exhausted.[8]

Injuries from spent gunshot, though not uncommon when round shot were in general use, have become comparatively rare since elongated gunshot with projecting studs have been introduced.

Such projectiles can only travel along the ground when still armed with considerable velocity. Whether travelling front forwards in a direct line, or turning on their axis as they proceed, their form and the opposition from friction caused by the studs quickly arrest their progress when the velocity attained by them is much reduced. Still toward the close of their course, and so long as any progressive or rotatory movement is retained by the shot, they have the same destructive power as spent shot of the old forms.

(*b*) **Rotation of projectiles.**—The rotatory motion impressed on projectiles interests surgeons only so far as the missiles used with portable fire-arms are concerned. In them the influence of this quality is most important, both as regards the production and also the course of wounds. The difference in the kind of rotatory motion imparted to rifle bullets from that which is impressed on the projectiles of smooth-bore muskets, has not a greater effect in correcting irregularities of flight, and thereby in meeting the requirements of combatant officers, than it has in producing results which demand the attention of medical officers. To estimate properly the influence alluded to, it is necessary to understand the difference between the movement imparted to a spherical bullet fired from a smooth-bore fire-arm, and that of a cylindro-conoidal bullet from a rifled weapon; for these different movements still exist in the two kinds of projectiles, at the time they are brought into collision with any body opposed to them.

Rotation of spherical projectiles.—When a round bullet is fired from a smooth-bore weapon, owing to windage, from the bullet not being made to fit the bore accurately, or from the iron tube becoming expanded by heat, the projectile while passing through the fire-arm does not maintain an even constant contact with the whole cylinder, but presses against the sides of the barrel at certain spots more than at others. Whatever portion of the side of the barrel the bullet is last forced against as it quits the muzzle of the weapon, it acquires a rotatory movement towards that side; for, being momentarily held, as it were, at that point, the escaping gas exerts a more active progressive force upon its opposite surface, which is not in contact with the barrel. Two movements are, therefore, impressed on the projectile: a movement of rotation, and a forward one, or movement of translation.

Another cause of a revolving motion being communicated to a spherical bullet is met with when the centre of gravity of the projectile does not correspond with the centre of its figure. This condition constantly happened when bullets were cast in moulds, and, when from the accidental presence of particles of air, or from the expanded melted lead being cooled rapidly on the outside, and so leading to a small vacuum somewhere in the interior, an even density was not obtained throughout their whole substance. If the centre of form and centre of gravity coincide, the pressure of the

volume of exploded gunpowder will be exerted equally upon the bullet provided it fits the bore of the fire-arm closely, and will only communicate progressive motion to it; but if the centre of gravity have not the same relation in respect to distance from the surface of the cylinder of the fire-arm as the centre of form, the force will be exerted unevenly. So far as the particles composing the bullet are concerned, a greater amount of force will be exerted on the half of the bullet on one side of the centre of gravity than on the other side, and, in consequence, a revolving motion in addition to the progressive motion will be impressed on it. The revolving motion will take place round an axis passing through the centre of gravity of the bullet.

As the rotatory motion is continued in addition to the progressive motion throughout the flight of the bullet, and as the resistance of the air is greatest against that side of the bullet which revolves towards it as it flies onward, a certain amount of deflection in its line of flight must follow. This deflection is a serious matter in a combatant point of view, as it leads to failure in hitting a particular object which may be aimed at, but is not of much moment in a surgical aspect, or is not of so much moment as is the particular direction which the rotatory motion follows relatively to the progressive motion.

Rotation of rifle projectiles.—From the foregoing description of the rotatory motion impressed on spherical projectiles and its causes, it is evident that, in the one case, whatever may be the part of the muzzle of the gun last touched by the bullet, or, in the other, whatever may be the position of the centre of gravity in regard to the centre of form, the rotation of the bullet will be always such that a line representing the axis on which the bullet revolves must cross, or be at right angles with, another line representing the line of its progressive motion. Whether the bullet be caused to whirl from right to left, or from left to right, or from above to below, the line of the axis of revolution will equally cross the line of flight of the bullet at right angles. Not such, however, is the axis of revolution when the bullet is a cylindro-conoidal one, and projected from a modern rifled weapon. Here the spiral rifling of the weapon, and certain arrangements of the projectile itself by which its substance is pressed into the grooves of the rifling, cause the bullet to be brought into perfect contact with the whole interior of the barrel; and at the same time, the rifling, by its spiral twist, impresses upon it a rotatory motion in an exactly opposite direction to that just ascribed to the spherical bullets. The rifle bullet is caused to turn round the long axis of the barrel as it is driven forwards towards the muzzle, and this same kind of rotation is continued after it quits the weapon. The axis of revolution of the cylindro-conoidal bullet as it flies through the air, instead of being across the line of flight as it is in the round bullet, is therefore coin-

cident with the line of flight. The spherical bullet turns like a billiard ball spinning across the table; the conoidal rifle bullet turns like a screw entering a piece of wood. The number of revolutions on its long axis made by an Enfield bullet at the moment of quitting the muzzle of the fire-arm was officially stated to be 194 per second, or 11,640 per minute; its progressive motion at the same instant being at the rate of 1,265 feet per second, or 25,300 yards per minute. The number of revolutions of the Martini-Henry bullet has been shown elsewhere to be 744 in a second of time on quitting the muzzle of the rifle, and its initial velocity to be 1,443 feet in a second.

The purpose of the combatant officer in thus substituting a determinate for an accidental course of rotation is to maintain the stability of the bullet in its flight on the same principle that a top is kept upright by the spinning motion, and thus to acquire the means of hitting with more certainty the object against which his aim may be directed: it is the surgeon's part to observe the effects when the objects aimed at are men, and the missiles have reached their destination. These results may be best considered under (*a*) 'effects on penetration;' (*b*) 'effects on course after penetration.'

Effects of rotation on penetration of projectiles.—The direct effect of the rotatory movement of spherical bullets not agreeing with their progressive movement is to lessen the number of chances of their penetrating the persons struck by them, when compared with the chances there would be of penetration if the progressive movement existed alone. The effect of the two movements being coincident, on the contrary, is to facilitate penetration. The generally rounded contour of the principal parts of the human body must be taken into account in these results. In the one case, when the revolution is at right angles to the line of flight, unless the surface offering resistance is directly opposite to the front of the projectile, so that this latter acts perpendicularly upon it; or, in other words, if the resisting surface present the slightest obliquity of inclination opposite to the projectile, whether this obliquity be obtained from the surface being elastic and yielding before the pressure of the bullet, or whether it be owing to the fixed and natural form of the part impinged upon, the direction of its revolution will assist in causing the projectile to glance or roll off. This effect will be the more marked if the surface against which the projectile impinges happen to be hard, such as the surface of some of the metal or leathern accoutrements covering the body; or if it be brought into contact with some of the bones which are placed superficially beneath the integument, such as the rounded cranium, or the body of a rib. In these latter cases, whether the skin be or be not penetrated at the point of impact, the bullet will have a tendency to glance off or to turn round the bone, and pene-

tration of the cavity will thus be avoided. The tough fasciæ spread round the muscles of the extremities will be sufficient to prevent penetration under the same circumstances. On the other hand, when the revolution is coincident with the line of flight, the revolving motion joins with the progressive motion, and both together assist in penetrating the surface opposed to the projectile. It screws itself in, point forward, as it were. Even though there may be a certain amount of obliquity in the angle of impact, so long as the spinning elongated bullet strikes the body or the surface of a limb at such an angle that resistance is offered to the progress of the apex of the bullet, the revolution of the bullet on its long axis will assist the apex in effecting an entrance. The more rapid the revolution of the projectile, the more its penetration will be facilitated.[10]

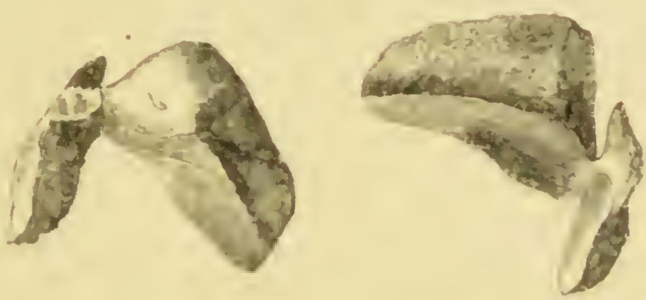
Effect of rotation on course of projectiles after penetration.—The different effects of the two kinds of rotation are equally manifested *after penetration* of the superficial textures of the body. The rotation of the spherical bullet will equally tend to divert it from a straight course on meeting any surface presenting sufficient obliquity within the body. And this affords one source of explanation of the circuitous and irregular tracks of round bullets when they were in common use. Such a bullet might enter the wall of the abdomen apparently almost in a straight line, but the obliquity offered by one of the layers of muscles pushed before it, might be sufficient to divert it into a circuitous course round the abdomen; while its progressive motion would still be sufficient to enable it to force an exit at a point opposite to that at which it first penetrated the abdominal wall. The same thing might happen to a joint protected by a rounded capsule, such as the shoulder: the opening of first penetration being in front, that of exit opposite to it at the back of the shoulder, but the joint unopened, and the bone unbroken.

The spinning of the conoidal bullet on its long axis will, on the other hand, constantly assist the projectile in taking a direct and onward course, by exerting exactly the same influence after penetration that it did in assisting the penetration itself. The change from the one kind of rotation to the other has therefore not only tended to increase the number of wounds in warfare, but has further had the effect of adding to their depth and severity.

Effect of the rotatory motion of a projectile being continued after cessation of the movement of translation.—There is one other effect of the rotatory movement of rifled projectiles, which may be briefly referred to. It is one which occurs when circumstances lead to the progressive motion being stopped without the motion of rotation being also arrested. Ordinarily, the same causes which put a stop to one put a stop to the other. But occasionally a bullet becomes so caught that it is unable to pursue a further course forward, and

yet sufficient movement of rotation remains to exert a turning action on the structure by which it has been caught. Such an influence may be observed when the apex of a rifle bullet comes into collision with the sharp edge of a thin bone, and when the bullet, in consequence, is partly bisected by its *vis a tergo*, or forward motion. In such a case, the divided surfaces of the soft lead are usually strongly marked by ridge and furrow lines, caused by the irregularly jagged edge of the broken bone by which the division has been effected; and the direction of these lines will frequently serve to illustrate the twisting force—resulting from the rotation of the projectile on its long axis—which has been at the same time exerted. The annexed drawing (fig. 25) is taken from an interesting specimen of a bullet in the Museum of the Army Medical Department connected with a wound of the skull, which exhibits nearly one complete turn on its long axis after it had been thus caught. It is a Russian conical rifle bullet, and has been

FIG. 25.



Drawing of a bullet partially cleft by the edge of a fractured bone, and showing some of the twisting effects of its movement of rotation.

nearly separated by an oblique division from the apex to the base; the two divided parts being only held together by a narrow isthmus of lead at one of the angles of the base of the section. This isthmus is twisted round on itself like a piece of cord, carrying with it a thinner section of the projectile, or that section which was most easily acted upon by the twisting force. The ridge and furrow lines on the separated surfaces of the bullet are contorted from the right to the left, indicating the direction towards which the rotatory force has modified the direction of the bisecting force, and affording a complete demonstration of the influence of the spinning quality under notice.

Although when the spinning force is first impressed upon the projectile, it is limited by the degree of spirality of the grooves of the barrel to one turn in a distance varying from 20 inches to 78 inches according to the rifle used, yet there seems to be reason for believing that the degree of turn, or the distance within which a complete spin takes place, constantly lessens from the

time the projectile quits the muzzle of the musket, owing to the greater opposition to the forward motion than to the spinning motion in its passage through the air. The resistance of the air to the forward motion causes the bullet to travel over a less space in each successive period of time, while, the velocity of the rotation being very little interfered with, the spirality of the rotation is proportionably shortened. At any rate, when the forward motion is stopped, or nearly stopped, by a substance capable of opposing sufficient resistance, the shortened turn may in some cases be rendered obvious to sight, as shown in the illustration. The question therefore arises, whether this revolving motion may not exert an influence in increasing the wounding effects on soft parts during the passage through them of rifle projectiles, especially when the surfaces of the bullets have become roughened or jagged, or when, from the effects of more or less opposition to their forward progress, they pursue their course with a certain amount of lateral oscillation, and not in a straight line. It may be readily understood that the width of the track may become considerably increased under such circumstances; and that even shreds of tissues may be caught and torn away by them in the act of revolution. This may be one means of explaining the wide gaps that are occasionally met with in the tracks of wounds made by comparatively narrow rifle projectiles, though no doubt the chief explanation consists in the fact that a large amount of the energy of such bullets is communicated to all the substances with which they are brought into collision, and that these in turn act as so many secondary projectiles on the other substances in their vicinity.

Persistent rotation of spherical bullets.—The influence of a continued revolving motion of round bullets after all forward motion had been stopped was formerly recognised in the conical forms of the flesh wounds at the bottom of which such projectiles had happened to lodge.[11] The bottom of the wound was found to be larger than the entrance, and this fact was attributed to the pressure and persistent rotatory action of the projectile after its loss of power to pursue a course forward. There seems to be no reason to doubt the accuracy of this explanation; the movement of rotation may equally well continue in the case of a small round bullet after its movement of projection has ceased as in the case of a spherical gunshot, such as was noticed when remarking upon the qualities of 'spent shot.'

Effects of the combined material and impressed qualities of projectiles just enumerated.—An acquaintance with the effects of the impressed and inherent physical qualities which have now been described, will enable an estimate to be formed of the destructive power of particular projectiles according to the relative amounts in which these qualities reside in them. In this way an explanation may often be found for the different degrees of gravity pre-

sented by wounds inflicted under apparently like circumstances, as well as for the varying results of the same treatment in wounds of any particular class. It has been shown that the principal changes which have been made of late years in the material qualities of bullets—in their form, dimensions, and substance—have each separately had the effect of increasing their wounding power; and still more so, the changes in the impressed qualities, in the mode of rotation, and the accelerated velocity which modern contrivances have succeeded in conferring on them. The result of the whole of these accessions of power combined is witnessed in the enormous amount of destructive energy which these missiles possess at all ordinary ranges, and the immense distance up to which their wounding power is retained. These effects have been practically demonstrated on a vast scale in the conflicts of Continental armies. They were sufficiently shown in our own service on the first occasion that British troops were armed in any large proportion with rifled fire-arms—when the Minié rifle projectiles were used in opposition to the musket bullets of the Russians at the battle of the Alma; and they have been equally manifested since in the various contests in which British troops have been engaged with half-civilised peoples. The increase in amount of surgical injury which is inflicted by rifled projectiles in individual wounds is a subject which can only be fully considered when the wounds themselves are described. But I may here mention a fact which occurred in a comparatively recent war, the last war in New Zealand, as it appears to afford a striking illustration of the different amount of surgical damage done by the smooth-bore musket bullet and rifle bullet under corresponding circumstances, solely in consequence of their differences in respect to the qualities which have been described in the preceding remarks. I refer to the very different terminations of the cases of fracture of the thigh-bone among the Maoris wounded by the Enfield rifle bullets of the British troops, and of the same fractures among the European soldiers who had been wounded by the smooth-bore musket balls of the Maoris. Nearly every case among the British troops treated conservatively terminated successfully; while every case, without exception, among the Maori soldiers treated in the British hospitals ended in failure. Not one Maori preserved life or limb after a gun-shot fracture of the femur. The distances at which the opponents were placed from each other, when the wounds were inflicted, were similar, they were treated by the same surgeons, and had the same hospital and climatic advantages. It was, in fact, the nature of the wounds which was so different. My friend, Deputy Surgeon-General Mackinnon, who served throughout the war, informs me that the thigh fractures of the British soldiers in their early stages bore no resemblance to the thigh fractures of the Maoris at corresponding periods, excepting that the fractures

in both were compound; in the former series of cases they were generally single fractures, while in the latter series they were always extensively comminuted fractures with proportionate increase of damage to the soft tissues in the immediate neighbourhood of the shattered bones. Remembering the great strength and hardness of the human femur, and the force necessary to smash it up into fragments, this marked discrepancy in the nature of the local injury, and in the amount of reparative energy exhibited, seems to demonstrate most clearly the great difference in the destructive powers of the two kinds of projectiles by which the wounds were inflicted—a difference sufficiently accounted for by their respective qualities as explained in the present and preceding chapters. The moral depression from which the Maori wounded doubtless suffered, in consequence of their reverses and disabled condition, was a superadded cause of hopelessness, so far as concerned their chances of recovery, but the main cause was that they were shot by Enfield rifle bullets, and not by musket bullets, like the English wounded.

CHAPTER III.

OTHER QUALITIES WHICH ARE, OR HAVE BEEN, SUPPOSED TO BE IMPRESSED ON PROJECTILES AND TO INFLUENCE THE NATURE AND CHARACTERS OF THE INJURIES INFLICTED BY THEM.

Of these qualities, two only (*c*) the heat of bullets, and (*d*) a supposed poisonous quality attached to them, require notice.

(*c*) **Heat of Projectiles.**—One of the earliest notions concerning gunshot wounds was that they were complicated with a certain amount of burning. It was supposed that bullets acquired so much heat by the resistance met with in their passage through the air, that they charred the surface of the wound which they inflicted in the flesh. The blackened aspect which is often presented by the edges of the opening made by a bullet,—which is in reality due partly to the direct effects of the contusion, partly to the ecchymosis of the structures immediately surrounding the opening, and not unfrequently also to the fact of the lips of the wound retaining some of the gunpowder or of its smoke which had been deposited upon the projectile at the time of its being discharged from the fire-arm,—doubtless gave rise to the idea. No doubt also a disposition to the belief existed in consequence of the still older conviction—one as old at least as the time of Aristotle—that lead was caused to melt by being impelled with rapidity through the air.

Aristotle quotes as an acknowledged fact the lead of flying darts or arrows becoming so heated as to melt; and both Ovid and Virgil write of leaden bullets becoming melted owing to the rapid flight to which they were impelled by the powerful force of a slinger's arm.[12]

The doctrine of the influence of the heat of bullets in producing some of the characters of gunshot wounds was first refuted in England by Thomas Gale, in his 'Treatise of Wounds made with Gonneshot, &c.,' published in July 1563. The first chapter of this treatise bears as the title of its contents,—'Gonnepowder is not venemous, *nother the shotte of such hotenesse as is able to warme the fleshe, much less to make an ascar.*' The arguments he adduces are the same as had been previously put forth in France by Ambrose Paré, and are obviously copied from him.[13] Since Gale's work, no English writer on gunshot wounds has entertained the notion that heat has a part in producing any of their characteristic features, but the idea has recently been revived, though in a different form. The very experiments which Paré and Gale made to refute the notion of 'adustion' have been recently repeated. Dr. Ernst Küster, in a paper read by him in 1874 at the Berlin Medical Society, mentioned that small bags of gunpowder had been suspended in front of iron targets by Dr. Schädel in Heidelburg, and fired at by rifles. The same result ensued as in Paré's day, for though the powder bags were repeatedly cut open by the bullets, in no one instance was an explosion caused.

Recent views on the subject.—The attention of modern surgeons was mainly drawn to the subject by the development of the law that impeded or arrested motion is converted into heat. Professor Tyndall, in a lecture delivered by him at the Royal Institution in June 1862, made the following remarks. 'Experiments and reasoning lead us to the remarkable law that the amount of heat generated, like the mechanical effect, is in proportion to the product of the mass into the square of the velocity. Double your mass, other things being equal, and you double your amount of heat. We, moreover, know the amount of heat which a given amount of mechanical force can develop. Our lead ball, for example, in falling to the earth, generated a quantity of heat sufficient to raise the temperature of its own mass $\frac{3}{5}$ths of a Fahrenheit degree. It reached the earth with a velocity of 32 feet per second, and forty times the velocity would be a small one for a rifle bullet. Multiplying $\frac{3}{5}$ths by the square of 40 we find that the amount of heat developed by collision with the target would, if wholly concentrated in the lead, raise its temperature 960 degrees. This would be more than sufficient to fuse the lead. In reality, however, the heat developed is divided between the lead and the body which it strikes; nevertheless it would be worth while to pay attention to this point to ascertain whether rifle bullets do not under some circumstances show signs of fusion.'

This question was believed by E. Hagenbach to be settled by an experiment which he made at Basle. Dr. Hagenbach asserts that his experiment has proved that when a conical lead bullet is fired from a distance of 100 paces with a velocity of 320 metres at an iron target, it is melted to a considerable extent. Around the point where the ball had struck, the target was spattered with lead in the form of a white star; the original bullet, which weighed 40 grammes, only weighed 13 grammes on being picked up; and melted lead was found in the vicinity of the target. According to Dr. Hagenbach's calculations, the mechanical equivalent in heat of the force expended in the ball, was just what was necessary to heat the bullet and fuse the melted portion of it,[14] but these calculations were subsequently shown to be below the mark by Mr. J. Bodynski. Mr. Bodynski asserts that by far the least part of the warmth developed was expended in melting the lead: the greater part disappeared in other ways, as through rebound, radiation, conduction, effect on iron plate, &c. (The calculations are given in the Appendix.) The correctness of these calculations has, however, been disputed by Dr. Hagenbach. In a later paper Dr. Hagenbach has adduced some evidence to prove that parts of leaden shot are actually brought into a molten state in wounds, when bones have been struck by them. He says that his friend Professor Aug. Socin, Director of a Military Hospital in Carlsruhe during the war of 1870–71, had shown him several shot extracted from wounds, in parts of which were to be seen the effects of melting, and in parts iridescent colours, leading to the conclusion that there had been a development of heat from the motion of the shot having been arrested by striking against bone. Professor W. Busch, of Bonn, has also expressed his belief that rifle bullets on striking bones actually become melted and divided into numerous slug-like particles, and thus add to their destructive effects in wounds.

Bullets assume such a great variety of forms under collision with bones, that very accurate observation is necessary before a conclusion can be arrived at that the appearances are the result of melting. I have observed a large number of bullets that have been arrested in their flight by collision with bone, but none that I have ever examined have given me the impression that their changed condition has been due to the effects of melting. The iridescent colours observed on certain bullets may have existed before the bullets were fired, for such colours may be well imagined to have been produced by a thin film of sulphuret of lead from the previous action of the sulphur in the gunpowder upon them. With reference to this subject, in March 1872 I wrapped up a small parcel of sulphur and enclosed it in several folds of white paper. At the same time an Enfield leaden bullet was scraped clean, so as to expose a bright metallic surface. The packet containing the sulphur and the leaden bullet were then

placed together in a glass stoppered bottle; the temperature at the time being about 60° Fahr. On the third day the bullet had lost its metallic surface, and instead exhibited iridescent colours similar to those which appear on the surface of molten lead.

To what extent wounds are affected by the heat of bullets.—The practical question, however, as regards surgeons resolves itself into this:—When a rifle ball at a high rate of speed is arrested in its flight by some part of the human body, is there any perceptible amount of heat developed in the wound, or such heat as can exert a direct influence on the character of the injury inflicted by the projectile? The correct reply is, I believe, that there is not. I have never from observation, nor from inquiry of wounded men, met with any condition that could justly be attributed to the effects of heat. It is easy to understand that when the motion of a rifle bullet, travelling with great velocity, is abruptly and completely arrested by collision with a rigid iron target, the lead may be partially melted as described, from the heat developed acting fully upon the apex, which has received the first and greatest force of the impact.

When an unyielding steel projectile is driven with immense velocity against a plate of iron several inches in thickness and passes through it, a very large amount of heat is generated by the prodigious force with which the two metals are brought into collision, by the resistance offered to the displacement of the iron, and by the mutual friction between the iron and the shot; so large, indeed, that Mr. Whitworth was able to turn it to a finely practical application. He used heat thus developed to effect the explosion of bursting charges within hollow projectiles; regulating by the thickness of their walls the time for the heat to travel through them, so that the explosion should take place on the other side of the iron plates which the projectiles were directed against, just when they had passed through them. But experiments show that when small projectiles are arrested by soft, moist, and comparatively yielding substances, no heat approaching the melting heat of lead, or a charring power, is generated. Such structures in the human frame fail to arrest the course of the bullet when it is armed with a high rate of velocity. They only arrest its progress when the energy of the bullet has been very considerably expended, and then the softer textures give way one after the other before it, lessening by degrees, and at last by their elasticity putting a final stop to its further progress. If the projectile be opposed by bone, its force, if moderate, may be wholly spent in breaking it up into fragments, to many of which fragments a considerable part of its motion is communicated, and among which it may remain more or less broken or distorted. Thus no perceptible amount of heat is generated, for the arrest of motion has been gradual, and much of it has been imparted to other substances. On the other

hand, if the momentum of the bullet be very high, the stoppage by the opposition of the bone will be only partial; part of the momentum will be expended in smashing up the bone, but the projectile still retaining sufficient force for the purpose, will travel onwards and escape. The moist condition of the organised structures of the human body, too, favours the dispersion of the relatively small amount of heat which may be developed under the circumstances described. The conditions are so widely different that observation of the amount of heat developed by the sudden total arrest of progressive motion in a rifle bullet which is carried at nearly its highest rate of speed against a fixed iron target, cannot warrant the inference that corresponding effects will take place in a bullet armed with the same velocity but coming into collision with a part of the human body. Practical experience, indeed, affords no evidence of the wound surfaces having been scorched by heat, neither when a projectile has completely traversed the tissues concerned, nor when its passage has been arrested in the flesh, or by the opposition of a bone.

Effect of the heat generated by collision with bones on the bullets themselves.—Although, however, the lead is not brought to a molten condition, nor to such a hot state as to burn or scorch the organic tissues wounded by it, there can be no doubt that when the progress of a leaden bullet travelling with great velocity is suddenly arrested by collision with bone, a certain amount of heat is generated in it, and, not improbably, sufficient to modify some of its physical characters. The lead may be rendered softer than it is at ordinary temperatures of the air, and in consequence be more easily altered in form or broken. Portions of its substance may be more readily cut away by the rough edges, or sharp spiculæ, of the broken bone, and become impacted in their substance, or scattered in adjoining structures. Professor Busch, of Bonn, before a meeting of German naturalists at Wiesbaden in 1873, described some experiments to prove that lead loses its cohesion in proportion as it is heated, and Dr. Küster stated he had obtained evidence of this fact by letting two bullets—the one cold, the other hot—drop from a height of about 6 feet upon stone. I repeated this experiment from a height of 11 feet, both with leaden and hardened bullets, but without obtaining very marked results. The rate of velocity acquired by the bullets in this slight fall was too low. While the flattened spot on a leaden bullet at 57° Fahr. was ·30 inch in diameter, on another heated to 320° Fahr. it was only increased to ·33 inch. On a Martini-Henry bullet at 57° Fahr. it was ·17 inch in diameter, in another heated to 320° Fahr. it was ·19 inch in diameter. But on subjecting bullets under similar differences of temperature to high determinate pressures the different effects produced were sufficiently obvious. A hardened Martini-Henry bullet subjected to a pressure of 378 lbs. midway

between its apex and base, at a temperature of 57° Fahr. was hardly at all indented. It was flattened at a very small spot to ·40 inch, while another at 320° Fahr., when subjected to the same pressure, was widely spread out, and reduced to ·15 inch in thickness. The bullets employed in these experiments are in the Museum of Military Surgery at Netley. This loss of cohesive force from the progressive motion of a leaden bullet being suddenly converted into heat may probably in part account for the extensive breaking up of its substance which is so frequently met with in gunshot fractures; and, if this be true, the aggravation of injury to the surrounding parts in consequence of the dispersion of fragments of lead will after all be partly traceable to the effects of heat. The observation is of interest, because it shows that the notions of the ancients regarding the generation of heat, and the softening of the leaden projectiles of slingers, were not without some foundation; and it is also not a little curious that a belief which had once held sway, and then been discarded for centuries, should now be revived in our own day, and be so far supported by the investigations of modern science.

The fusing point of an alloy of 1 part of tin and 12 parts of lead is nearly 100° Fahr. lower than that of pure lead. It might be expected therefore that the heat generated by arrest of motion would cause more injurious effects with the Henry-Martini than with leaden bullets. On the other hand, the hardness resulting from the combination of tin and lead must be taken into account; and it will require more careful observations than have yet been made to determine the extent to which the Henry-Martini bullets or the wounds inflicted by them will be influenced by the heat thus developed, as compared with what happens when bullets of pure lead are employed.

(*d*) **Poisonous influence of projectiles.**—The belief which once existed that a musket projectile had a poisonous effect not only upon the structures mutilated by it, but also upon the whole constitution of a patient, is chiefly noticed here on account of the serious influence it exerted for many years upon the treatment of gunshot wounds. The primary appearances of the injury, the same that originated the idea of the structures having been burned, the sloughing of the track of the bullet, and the surrounding inflammation, no doubt encouraged this erroneous conviction: but it would not have held its ground, had it not been for the fatal results which from time to time followed gunshot wounds from various forms of septic poisoning. It is evident enough, now, that this poisoning was due in part to the foulness of the discharges from the wounds and the unhealthy condition of the neighbouring structures, brought about by the irritating applications to which the wounds were subjected; but more especially to the great neglect which prevailed generally of hygienic rules,

to the continuous unsanitary and depressing circumstances under which the wounded men were treated, and not to any special influence of the projectiles by which the original injuries had been inflicted.

To Ambrose Paré is certainly due the most early published attempt to refute this error. The first of his treatises, which had this object in view, appeared in the year 1545. Paré has left a very honest and simple account of the chance way in which he discovered that burning the wounds with scalding oil, which he found to be the common mode of treatment with a view to get rid of the poison when he was first employed in field surgery, was not only unnecessary but even hurtful;[15] and how he then came to the conclusion that 'wounds made by gunshot are more refractory and difficult to cure than others, not because they partake of any poisonous quality, but through the fault of some general cause, as the ill complexions of the patients, the infections of the air, and the corruption of meats and drinks.' Paré answered those who thought that the poison was derived from the gunpowder, by showing the harmlessness of its ingredients, separately and combined, when applied locally to parts of the body or taken internally; and he replied to others who thought that the poison sprang not from the gunpowder but from some poisonous substance mixed with the lead, or from the bullet being steeped in some poisonous liquor, by showing that if this poisoning could be practised, the flame of the ignited powder in the gun would cause the poison to be dissipated before it could reach and infect a person who might be wounded by the bullet.

Persistence of erroneous ideas among Continental people on the poisonous qualities of fired bullets.—But though Paré refuted the doctrine of the poisonous nature of gunshot injuries, not only by arguments but by his successful treatment with simple remedies, the belief continued to prevail for a long time after Paré wrote not only among combatants but also among surgeons. More than a century after Paré's first work on the subject was printed we find, even in Paré's own country, a systematic work published on gunshot wounds in which the author, Pierre Dailly,[16] states that the experience he had had in armies had made him conclude that gunshot wounds are truly poisoned wounds. Dailly advances a long series of arguments to overthrow the arguments of Paré and of all those who held the idea that such wounds were not venomous. Dailly's directions for the treatment of these injuries are based on the assumption that the most important point is to get the poison out of them. His treatment included scarifying the edges of the wound, applying cupping glasses, dilating the track by incision, so that the poison might flow away with the blood, applying dressings calculated to oppose the poisoned condition of the wounded structures, while general bleeding, purging, and

lowering remedies were resorted to with a view to clear the constitution of the patient of the virus circulating in it.

Even so late as the year 1848, on the occasion of the insurrections in Paris, the notion of musket balls being poisoned, and being one cause of the mortality of the wounds inflicted by them, prevailed to such an extent in France that several eminent surgeons thought well to speak on the subject at the Academy of Medicine. M. Roux, in his account of the wounded persons who had been admitted under his care in the Hôtel-Dieu, stated on this point: 'As to the nature of the projectiles, neither direct examination, nor any peculiar symptom observed in our patients, raised suspicions regarding it. I do not believe that they were poisoned.' [17]

M. Velpeau, on the occasion of the same discussions at the Academy of Medicine, gave some explanations which appeared to have for their object an exculpation of the prevailing notion of gunshot being poisoned wounds. 'There is still,' he said, 'a question of the poisoning of gunshot wounds on every occasion of insurrectionary fighting by armed citizens. It is not that I believe in the poisoning of the wounds by the projectiles themselves; I can scarcely conceive it to be possible for bullets to deposit in the tissues which they traverse any substance capable of compromising the life of a wounded man; either I am very much deceived, or all that has recently been said on this point should be classed as fables created by fear or love of the marvellous. But the venomousness of gunshot wounds can be regarded in another manner; such wounds have no need to seek for poisons from without, for they contain the principles of poisoning in themselves. The layer of tissue, ground up by the projectile, decomposes, quickly becomes putrid, and stagnates in the midst of the living parts. One knows with what promptitude animal matters become decomposed under the influence of heat, moisture, and contact with animal tissues. Who can contest that, in decomposing, the elements of putrefaction will not often give rise to dangerous compounds, if in some way they happen to pass into the circulation? Is it not allowable to say therefore that gunshot wounds contain a veritable poison, and that the accidents they so frequently give rise to are sometimes due to this kind of cause?' [18]

Mutual recriminations on the subject during the Franco-German war.—That the notion has not altogether died out on the Continent in our own time, has been shown by the accusations of the use of poisoned bullets among the mutual recriminations which were published during the war between France and Germany in 1870. A correspondent to a German journal, dating his letter from Rheims on September 12, 1870, wrote: 'We can say with justice that the use of the mitrailleuse is contrary to the existing rules of warfare; it causes a wound with ragged and uneven edges, which is most

difficult to heal: the difficulty arising in all probability from the fact that the bullets of the mitrailleuses contain a calcined poisonous substance in the lead;' and similar accusations appeared from time to time during the war.

Views regarding the poisonous qualities of bullets in Britain.—Paré's views, put forth by Gale, no doubt exerted a beneficial influence in shaking this error in England, but that it continued to prevail may be traced in the views of surgeons for many years after Gale wrote. Clowes, while not admitting gunshot wounds generally to be poisoned wounds, had no doubt they were so occasionally. He even performed experiments to test whether the flame of ignited gunpowder could exert such an influence, during the discharge of the shot, as to destroy any poisonous material which might previously have been impressed on the bullet, and he considered that his experiments proved that the flame 'could not burn out the impression of a poisoned bullet.'[19] It is difficult to say when the idea that gunshot wounds were complicated with poisonous influences finally died out in this country, but it certainly does not appear to have held its ground so long as it has on the Continent. Wiseman, in his works, repudiates the notion, and attributes the origin of the belief to the fatal results of the local inflammation and gangrene, induced by the improper applications used in dressing gunshot wounds, and we find scarcely any reference to it in the works of subsequent English writers. Had bullets charged with fulminate of mercury and the other explosives been employed in the warfare of former days, there would have been some ground for the belief that the wounds caused by them were complicated with 'adustion and venom;' but, without these modern refinements, nothing but the darkness which obscured all branches of scientific inquiry could have permitted the notion to have taken the firm root it did in the minds of so many physicians and surgeons engaged in treating gunshot injuries. That the error should have widely prevailed among combatants, and that it should have maintained its hold, supported by prejudice, hate, imperfect information, and credulity, notwithstanding the progress of learning, is no more to be wondered at than the existence of numerous other errors equally destitute of any foundation of truth.

CHAPTER IV.

(B) ON THE CONDITIONS APPERTAINING TO THE PART OR PARTS OF THE BODY INJURED, BY WHICH GUNSHOT INJURIES ARE MODIFIED IN THEIR PRIMARY CHARACTERS AND DEGREES OF GRAVITY.

THESE conditions are comprised in (*a*) The angle of impact, or relative position of the part struck to the projectile striking it; and (*b*) the anatomical situation of injury; together with, when penetration is effected, the course the projectile takes, and the depth to which it penetrates in the body.

(*a*) **Angle of impact.**—The usual consequences of the smaller forms of projectiles striking the surface of the body in a direct or nearly direct line, or coming into collision with it at certain angles of obliquity, have been already sufficiently described when the different kinds of rotation impressed on musket and rifle projectiles were explained. There remain to be mentioned certain peculiar effects which occasionally result, when massive projectiles impinge against portions of the surface of the body at a very acute angle, or pass in nearly a parallel direction across them.

Internal damage without external marks from gunshot projectiles.—Among the wide variety of injuries from gunshot, surgeons have frequently met with cases, in which serious internal mischief has been inflicted, without any external marks of violence to indicate the fact of its having resulted from the stroke of a projectile. These accidents have usually resulted from grape or round shot, or from a large fragment of shell having a smooth and convex surface. A viscus of the abdomen, the liver, stomach, bladder, or part of the intestines, has been lacerated, yet no bruising of the parietes has been observed: a strong tendon like the tendo-Achillis has been ruptured, without any mark having been left by the shot on the skin; symptoms of cerebral concussion have shown themselves, or rupture of one of the sinuses and fatal effusion of blood occurred, yet no lesion of the scalp has been detected.[20] The records of most campaigns afford examples of such wounds. Even bones have sometimes been comminuted without any wound of the integuments, or change in the appearance of the skin to indicate the injury. Two cases occur in the French records of the Crimean war of fracture of the forearm by round shot, without any apparent external lesion: in one of these the internal structures were reduced to a mass of pulp. A similar injury of the forearm occurred in our own army. In another instance, the bones of a cranium were shattered into fragments by a cannon shot, while the scalp remained entire.

The following cases, which were communicated to me by my

friend Inspector-General F. Innes, appear to be such instructive examples of the kind of injury I am describing, that I am induced to quote them as further illustrations.

During the Indian mutiny, when Havelock's field force was advancing on the Alumbagh, a gunner of Maude's battery, during a halt, lay along his gun to rest himself, the ground being very wet at the time. While lying in this posture, a round gun shot glanced along his right thigh, passed obliquely across his abdomen and chest, and then smashed the upper part of his left arm. The trouser was not torn, but portions of some pleats of his knitted vest were cut away by the passing ball, and corresponding holes were left in the garment. Neither the skin of the thigh nor that of the trunk exhibited any signs of injury. The arm was amputated at once. Two or three days after the operation, Dr. Innes, who was in charge of the field hospital at the Alumbagh, had his attention called to the patient's thigh. There he found a large slough on the inner aspect nearly as broad as his hand. This slough extended deeply enough to expose the femoral artery in the superficial part of its course. No slough nor discolouration took place on the trunk, nor was there any visceral disturbance; so that it was obvious the shot had hit the thigh, but had not touched, or at least exerted any downward pressure on, the abdomen or chest during its passage, although it had torn away pieces from the folds of the man's jersey. The thigh had been contused by the shot, though not visibly so; the trunk had altogether escaped.

About the same time, Brigadier-General Sir D. R., while with Lord Clyde's force advancing to the relief of Lucknow, met with the following accident. A round shot glanced across the back of his neck, and cut away the back of the collar of his uniform coat, the shirt underneath, and part of a hair chain. The skin was unbroken, and showed no traces even of a bruise, yet there was hardly any doubt, from the first, that it had been compressed, for a certain amount of general paralysis immediately followed the passage of the shot from concussion of the spine. Subsequently, the skin sloughed away as well as the subcutaneous cellular tissue, and a deep sore, necessitating long treatment, resulted. The fact of the injury it had been subjected to, as well as its severe nature, were thus sufficiently proved.

Similar injuries from shell fragments.—As already mentioned, it is not only by round shot that injuries of the kind described are produced; they also occasionally result from projectiles of irregular forms. An officer of the 42nd Highlanders, Captain F., met with his death in the Crimea from an injury to the abdomen. He was struck across the epigastrium by a large fragment of shell weighing 22 lbs., while he was sitting under cover of a parapet in the trenches. He fell prostrate, and shortly afterwards died as he was being carried up to camp. There was not the slightest bruise

or discolouration of the skin, no swelling, no indication of internal mischief apparent to the eye, and some officers who saw him at the time of his death would hardly credit his having been hit. But the evidence of those who had been with him in the trenches left no doubt as to his having been struck by the fragment of shell, and his symptoms showed that his death was due to internal hæmorrhage, consequent on the injuries it had inflicted.

Further explanations of such injuries.—The difficulty of reconciling the several facts noticed in such instances, together with the vague descriptions by patients in general of the sensations they experienced at the moment of being wounded, the erroneous impressions made upon even enlightened observers [21] owing to the almost instantaneous manner in which such wounds are inflicted, and the absence of evidence, by sight or otherwise, of direct contact of the projectiles, led the majority of surgeons for many years to find an explanation for these injuries in the supposition that masses of metal projected with great velocity through the air might cause them indirectly by aerial percussion, or, as it was usually called, by the 'wind of the shot.' [22] It was believed either that the air was forcibly driven against the injured part in consequence of powerful pressure from the missile during its flight; or, that a momentary vacuum was created as it flew past, and that the forcible rush of air to refill this blank was the origin of the hurt. Some, however, doubting the correctness of this theory, sought other modes of explanation. Dr. Spence, a surgeon of the Royal Navy, argued that such accidents were due to light substances, as pieces of canvas, rope-yarn, parts of bedding, &c., being carried along by a ball, and then being brought, with great velocity, into contact with the part of the body injured.[23] Electricity was also called into aid in explaining them.[24] All these hypotheses are now abandoned by most military surgeons, though a strong belief in them still exists in the minds of many combatant officers.[25] So many observations have been made of gunshot passing close to various parts of the body, as near as conceivable without actual contact, without any such consequences happening as those which have been attributed to windage,[26] as to lead to the almost necessary conclusion that the theory must have been in all instances fallacious. Portions of uniform and accoutrements have not unfrequently been torn away by shot without injury to the soldier himself. Cases are on record in which hair has been shaved off from the head, and the external ear and other prominent parts of the body have been carried away by gunshot without further mischief.

Modern views on the subject.—The true explanation of the phenomena observed in cases of so-called 'wind contusions' is to be found in the peculiar direction, the degree of obliquity, with which the missile has happened to impinge against the elastic skin; to-

gether with the relative situation of the internal organs injured to this missile, and to other hard substances in their immediate neighbourhood. The surface itself is not directly torn or cut into, because the impact of the projectile has not been sufficiently direct to effect an opening; but the parts beneath are crushed by the pressure to which they have been subjected under the combined influence of the weight and momentum of the shot on the one side, and some hard resisting substance on the other. Thus, on a shot passing across the abdomen, the ready mobility and elasticity of the skin may enable this supple structure to yield by stretching to the strain to which it is exposed, and to descend into the soft structures beneath, while viscera are ruptured by the projectile forcing them against the vertebral column. In a similar way, the weight of a ball passing obliquely over a forearm may possibly crush the bone between itself and some hard substance against which the arm may be accidentally resting, without producing lesion of the interposed skin. The crushing impulse fails to act on the yielding integument, but expends itself on the hard resisting parts beneath. In cases where the organ of vision has been injured, the ball has probably glanced along the forehead or upper part of the cheek, producing concussion of the optic nerve or some other ocular lesion, while the yielding of the skin and whole head to the weight brushing across it has prevented the occurrence of any obvious external injury.

It seems probable that in most, if not all, the instances in which these injuries have been produced by round shot, the peculiar result which has ensued has been partly due to the shot having *rolled over* the surface covering the injured structures; the movement of rotation being due either to the centre of gravity not coinciding with the centre of form, or to circumstances having impressed it on the projectile at the time it was discharged from the gun, in a somewhat similar way that rotation, as already explained, is impressed on spherical bullets at their last contact with the barrel of portable smooth-bore fire-arms.

The first Baron Larrey, who examined many fatal cases which some were inclined to attribute to 'vent de boulet,' has related that he always found so much internal disorganisation as to leave no doubt in his own mind of its being the result of pressure by the projectile, and gave the following explanation of the absence of superficial lesion. He argued that, in such cases, the surface of the body had been struck by a cannon ball in the latter part of its flight, when the ball had undergone a change of direction from nearly straight to curvilinear. In such a condition, balls would turn round a part of the body, as a wheel passes over a limb, instead of forcing its way through it: and while the elastic structures would yield to the force, bones and muscles offering more opposition would be bruised or broken. While agreeing with the

probability of the explanation afforded by the existence of a revolving motion in the shot, and its influence in the production of the peculiar injuries under consideration, there seems to be more reason for the belief that this motion had existed in the shot throughout the whole line of its flight, from causes previously referred to, than that it only occurred towards the last part of it.

It is not unlikely that in some of these cases, especially those involving visceral cavities, the remarkable absence of superficial ecchymosis may be partly attributable to the draining of the surface by the rapid effusion of blood within. Violent spasmodic muscular contraction may also partly contribute to the effect in some of the lesions, such as those in which rupture of tendons has occurred without marks of external injury, as well as the direct blow.

Remarkable qualities of the tegumentary covering of the human body.—The peculiar distensibility, elasticity, and toughness of the skin are, however, the most marked and constant conditions in these injuries. These qualities of the tegumentary covering of the human body are continually exhibited in many ways, but in no way is the remarkable extent to which they exist so forcibly shown as it occasionally is in gunshot injuries. Everyone is familiar with cases where bullets have entered the body with great force, traversing all the tissues including bone with ease, but which are yet found lying somewhere just beneath the skin, by the elasticity and resistance of which their further progress has been prevented. We see the same qualities manifested, sometimes in a remarkable degree, on the integuments of parts of the body which have been subjected to sudden violent force from explosions of gunpowder. Even in those parts of the extremities where the bones are placed at comparatively little distance beneath the integument, as in the hand and forearm, leg and foot, the bones will be frequently found crushed and comminuted, strong tendons torn and muscles pulpified, and yet scarcely any lesion will be exhibited in the skin on the side against which the explosive force has been directed. There may be local rents of the skin on the opposite side, but these will have resulted from some of the long fragments having been propelled through it. These effects are sometimes witnessed in the accidents which occasionally occur at artillery practice from the premature explosion of gunpowder.

The following seems worthy of being placed on record as a notable illustration of the power of resistance against gunshot injury possessed by the common integument of the body. On the day of the battle of the Alma, while the men of the 42nd Regiment were lying down in rear of the vineyards previous to the advance of the First Division, a round shot struck the ground about 20 yards in front of the first line of men, bounded, and in its fall struck Private Campbell in the abdomen and killed him

instantaneously. After the action, on the body being raised for burial, it was found to be exceedingly heavy, and, on examination by Assistant-Surgeon Mackinnon of the regiment, who was present, the round shot, about a 24-pounder, was found lying in the abdomen imbedded in the viscera. The integuments in front had not been extensively carried away; in fact, the length of the wound seemed less than the diameter of the ball, part of the surface of which only was visible through the opening. The integuments of the back were not in the slightest degree broken, though they were stretched tensely under the mass of iron, the round surface of which was presented to the hand on touching the back, instead of the prominence of the spinal column. The spine had been ground to pieces and pushed aside with the mass of other disintegrated structures; but the elasticity of the skin had preserved its texture entire. When the body was lifted from the ground the shot bulged out in a pouch of the skin of the back, by which, notwithstanding its weight, it was still retained.

It is not often that we are able to witness the qualities of the skin, just described, manifested as conspicuously in the injuries that occur in civil life as they constantly are in those met with in military practice. But in the following instance they were exhibited as forcibly as in the case last narrated. In June 1870, a railway train, consisting of three carriages, a break van, and an engine weighing 32 tons, passed over a young man while he was lying across one of the rails of the line of railway near the Euston Square station. On examination of the body afterwards at University College Hospital, no wound was observed on the surface, but on opening the abdomen all the abdominal muscles were found completely cut through horizontally, and retracted, leaving a gap from 5 inches to 6 inches in width. The muscles of the back were in the same condition. The right kidney was cut in half. The transverse colon and a large portion of the ileum were cut away, detached, and lying free in the abdomen. The body of the third lumbar vertebra was crushed literally to powder. In short, everything was divided except the skin; the man was actually cut in half, but the continuity of the tegumentary covering prevented this fact from being rendered obvious until the post-mortem inspection exposed it to view.[27]

(*b*). **The anatomical situation and course of injury.**—The special characters of wounds, and their varying degrees of gravity, which depend on the situation of the part of the body injured, and on the course taken by a projectile after penetration, will not be considered here; they are manifestly subjects which can only be properly discussed when wounds of particular anatomical regions are treated upon.

SECTION III.

ON THE CHARACTERISTIC FEATURES, AND DISTINGUISHING SIGNS, OF GUNSHOT INJURIES.

Introductory remarks.—Having considered the leading qualities of the projectiles by which gunshot injuries are produced, and their nature and gravity influenced, I now proceed to describe some of the principal features of the injuries themselves. These may be most conveniently studied under (1) the external appearances, or those presented to view according to the kind and quality of projectile by which the injury is inflicted, and (2) the internal conditions of gunshot wounds, also according to the kind and quality of projectiles causing them. The former of the two divisions may for convenience be again subdivided into injuries produced by solid and those by gaseous projectiles. The injuries produced by small shot in general use for sporting purposes present special features, and they will be separately described.

CHAPTER I.

CHARACTERISTIC FEATURES OF INJURIES PRODUCED BY SOLID PROJECTILES.

The injuries produced by solid projectiles are of two kinds: contusions and wounds. The features of gunshot contusions will be first described, and then those of gunshot wounds.

Contusions from Solid Projectiles.

Simple gunshot contusions.— Superficial contusions produced by projectiles striking the body in a direct line, but with their force in a great measure expended from the distance they have travelled or from any other cause, do not differ in appearances any more than they do in their nature from contusions produced by ordinary means. The usual signs of contusion are presented in both cases alike, and they equally vary in degree and extent according to the force and shape of the instrument by which they have been pro-

duced; and also, in some measure, according to the nature of the part struck, whether some thick layers of muscular tissues lie beneath it and these tissues be relaxed or in a state of tension, or whether it overlies yielding organs, such as the moveable viscera of the abdomen, or covers some of the superficially placed bones of the body.

Contusions from glancing gunshot.—If the projectile be a heavy one, as a gunshot or piece of a large shell, and it strike the surface very obliquely and yet so lightly as not to break the skin, there will sometimes not be presented at any period of the case much external evidence of the mischief which has been inflicted on the anatomical structures beneath the surface; sometimes the blow will be followed by great superficial ecchymosis and general swelling. In the latter case, however, the ecchymosis will often not exist at the first onset to such an extent as to afford an indication of the real amount of mischief which has been done by the projectile. Indeed, an unwary observer may be easily thrown off his guard by the small amount of external evidence of injury under the above-named circumstances, and be led to state that after a day or two the person struck will feel no inconvenience from what has occurred. But in almost all such cases the injury done will be found to extend to a considerable depth, and generally will be much more grave at that depth than it is at or near the surface. This kind of injury has been sometimes termed the 'brush of a shot,' to distinguish it from the injury formerly attributed to windage, the 'wind of a shot,' in which no external evidence whatever of the contact is presented either at the time or subsequently. An account of these peculiar injuries has been already given.

Indirect contusions from gunshot.—An interesting class of contusions is occasionally met with among gunshot injuries, in which the injured skin and subjacent parts are not struck directly by a projectile, but suffer from the force being communicated to them either by transmission through intervening parts, as when violent momentary stretching, or intense vibratory agitation propagated through them, becomes concentrated on particular points, or else by violent commotion from the original impulse of the projectile acting separately on a part remote from the point of impact. In this way alone can be explained the occasional accidents that occur of severe ecchymosis not only existing in the immediate neighbourhood of the part struck by a projectile or continued to some distance from it, but also in other parts at a greater or less distance away from the seat of direct injury.

Contusions propagated in the manner referred to from a centre of injury, whether this be a contusion or open wound, will not always manifest themselves immediately. Thus, if part of a limb be carried away by shot or shell, it will not unfrequently be observed several days afterwards that some of the parts above the

wound—parts which had not seemed to be at all involved in the injury at first—exhibit the ordinary signs of contusion. The condition of the parts is just the same as if they had been directly contused, and they require the same treatment as if they had been. It is necessary to be prepared for the liability of adjoining parts to assume this condition when primary amputation is performed for a gunshot wound. It will sometimes happen, when a limb has been smashed by a heavy projectile, that the surgeon, with a proper desire to amputate as far from the trunk as practicable, will perform the operation through adjoining parts which seem quite unaffected by the original injury, the skin being natural in colour, and the anatomical structures through which the knife is caused to pass being free from visible infiltration of effused blood, and otherwise presenting a normal aspect; and yet, shortly after the operation, or after reaction has set in, the surface of the remaining part of the limb will exhibit the usual discoloration of ecchymosis, darkest near the line of incision, and gradually lessening in hue as it becomes more distant. The limb, too, and the stump will become swollen and œdematous, and from the latter there will exude a sero-sanguinolent discharge. These changes are undoubtedly due to the violence to which the organic structures of the upper part of the limb were subjected at the time of the original wound. Such a case furnishes an example of one of those indirect contusions from gunshot in which the effects differ from those of direct contusion only in the circumstance that a longer time has to elapse before they become manifest and are rendered obvious to sight.

Gunshot contusion with fracture of bone.—When a heavy shot or fragment of shell has struck one of the extremities and produced a fracture of bone, without an open wound of the soft coverings, the amount of ecchymosis of the surface presented again varies very greatly in different cases. Whatever evidence of contusion may be offered to view, however, the soft parts between the seat of fracture and the surface struck by the projectile are usually so damaged that the nervous influence necessary for the maintenance of vitality is destroyed or greatly blunted, and the circulation of blood through a great part of their structure is stopped, or at least very greatly impeded. A condition is then presented in which mortification follows as an almost unavoidable result.

Wounds from Solid Projectiles.

Gunshot wounds in general.—The external distinguishing signs of penetrating gunshot wounds are generally manifest enough. The general dimensions of the opening made by the shot sufficiently show whether it has been made by a small-arm bullet, a large grape shot, or a still larger gun-shot; its shape, whether it has been

made by a round projectile, by a fragment of a shell, or an irregular splinter of some secondary missile; while the aspect and condition of the lips of the wound, and of the structures immediately surrounding it, sufficiently mark it as not being one inflicted by a stabbing or cutting instrument. Although possessing certain universal characteristics however, gunshot wounds vary very considerably in appearance, according to different circumstances, some of which I have referred to elsewhere. Especially may be mentioned particular differences in the forms of the missiles causing the injuries; in their speed; in the part of the body struck; in the position of the patient relative to the projectile at the time of injury; and lastly, differences in the lapse of time after its infliction at which the wound is seen. I proceed to describe some of the variations in the appearances of gunshot wounds which depend on the influence of the several causes just enumerated.

Gunshot at full speed.—When a heavy shot or an unexploded shell at full speed strikes in direct line a part of the body, the missile carries away all before it. If the head, chest, or abdomen, be opposed to the shot, a huge gap having a general correspondence with the size of the projectile is effected, the adjoining viscera are scattered, and life is, of course, at once extinguished. If it be part of one of the extremities which is thus carried away, the end which remains attached to the body presents a stump with a nearly level surface of darkly contused, almost pulpified, tissues. The skin and muscles do not retract, as they would do had they been divided by incision. Minute particles of bone will be found among the soft tissues on one side of the wound, but the portion of the shaft of the bone remaining *in situ* will probably be found entire.

Gunshot at diminished speed.—If the projectile have ricochetted before striking, and in any case where the force of the shot has been partly expended, the extremity, or portion of the trunk may equally be carried away, but the laceration of the remaining parts will be usually greater. The integuments will be more torn; the surface of the wound will be less even; muscles will be separated from each other and hang loosely, offering at their divided ends little appearance of vitality; spiculæ of bone of larger size will be found among them; and the remaining portion of the shaft will probably be found shattered and split for some distance above its principal line of division. The injury to nerves and vessels will also usually be proportionately higher and greater. A quantity of clotted blood, dark in colour, will be intermingled with all the torn and contused structures of the injured part. Occasionally it happens, even where a limb appears to have been struck in direct line by a gun-shot retaining immense power, that the parts below are nevertheless not completely detached; they remain connected by a portion of the integument, on which the bone, reduced to

minute fragments, is mixed with the contused muscles and other soft parts in a shapeless mass.

Spent gunshot.—If the speed of the shot be still further diminished, so that the missile becomes what has been explained as a 'spent-shot,' there will not usually be removal of the part of the body struck by it, but, nevertheless, irreparable mischief will generally be done owing to the weight of the mass of metal of which such a projectile consists. The external appearances presented at the site of injury will be general laceration and contusion of the soft parts, more or less deep and diffused according to the direction and amount of moving power retained by the shot; or they will be confined to ecchymosis, generally extreme, and tumefaction, with but a single wound of limited extent; or even these external evidences of injury may be wanting, and only a slight graze of the surface be presented notwithstanding the existence of serious internal disorganisation.

Slanting gunshot.—Should the shot strike in a slanting direction, the external appearances of the wound will be similar to those described above, according to its velocity, modified in depth and extent by the degree of obliquity with which the shot is carried into contact with the trunk or extremity wounded.

Wounds from shell fragments.—Large fragments of heavy shells generally produce immense laceration and separation of the parts against which they strike, the wounds presenting very jagged and irregular edges according to the forms of outline of the fragments, but they do not usually either carry away or mash the structures in the same degree as gunshot. Ordinarily the line of direction in which they move forms a more or less acute angle with the part of the body wounded, and the injury done is rather superficial than deep. When a fragment of shell happens to strike in a more direct manner, and the edge comes first into collision with the body, it will usually penetrate and sink beneath the surface. The wound then, though linear in general character, will have a certain curved form in accordance with the curve of the fragment; its margins will be irregularly jagged; and its external dimensions will be mostly smaller than those of the fragment itself, from the projectile not having had force enough completely to destroy the vitality and elasticity of the skin and other soft parts through which it has entered, so that these structures partially close around the wound, and contract the size of its opening.

Wounds from bullets at their highest rate of speed.—The projectiles fired from rifles and other portable fire-arms, when they have force enough to penetrate the body, and when they enter perpendicularly, or nearly so, to the surface, leave one or more openings, the external appearances of which also vary according to the form and velocity of the projectiles by which they are caused. The appearances of a wound from a rifle bullet at its

highest rate of speed may be sometimes witnessed in cases of suicide. A soldier, when thus destroying himself, mostly stoops over his firelock, presses its muzzle somewhere about his head or the upper part of his body, and fires it off by means of his great toe, having first removed his boot and sock for the purpose, or by pulling down with his foot a piece of cord, which he has previously tied to the trigger. The muzzle is often applied beneath the chin. In such a case a circular hole without any puckering or perceptible inversion of the marginal skin forms the wound of entrance. There is found to be a positive loss of substance, a portion of skin and subjacent tissue being punched out, as it were. The edge of the opening is blackened and burned; if hair be worn, it is singed; and there is dark discolouration of the integument for one or two inches round. The vertex of the head is shattered; fragments of the parietal and occipital bones, together with small portions of the brain, are carried away with the bullet and scattered about;[1] those bones which are not broken, are loosened or separated from their sutures; the great mass of the brain is torn to pieces, but held within the cranium by its membranes; the brain substance is pulpified, blackened in parts, and presents a marked odour of exploded gunpowder; the base of the skull is probably shattered into fragments. The superficial vessels of the face are distended and gorged with blood, and there is evidence of blood having escaped by the nose and ears. These effects are not wholly due to the passage of the bullet, but partly to the smoke and the intensely heated flame from the ignited gunpowder jetting out at the mouth of the musket, and in part also to the expansive force exerted within the cavity of the cranium by the volume of gas resulting from the explosion. The disruptive effects are increased by the violent wave-like impulse communicated to the substance of the brain itself by the gas and the projectile.

The appearance of the opening will be different if the part against which the muzzle is placed is not soft like the parts immediately below the floor of the mouth. If the muzzle be placed against the true chin, the bullet and combined volume of gas acting with immense force against the skin, supported as it is here by the maxilla immediately above, will cause a large lacerated gap to be exposed at the wound of entrance. This is due to the rebound from the hard subjacent bone, and lateral diffusion, of part of the volume of gas. A pistol pressed and discharged against the skin covering a rib will from the same cause make a very large opening, much larger than the opening of exit, should the bullet have force enough to pass completely through the chest. Other effects follow in each case from the shattering of the bone first struck by the projectile.

Wounds from bullets near to, but not touching, the skin.—If the mouth of the musket be not actually pressed against the chin, but

is held a short distance, not more than a few inches, away from it, then the condition of the wound of entrance is widely different from that above described. In a case of this kind the wound of entrance will be large, ragged, and excavated, while the torn and denuded tissues will be more or less scorched, blackened by smoke, and studded with grains of unexploded powder. The force of the gas escaping from the rifle exerts a destructive power not only in the immediate wake, but also around the sphere, of the projected bullet. The dimensions of the gap effected in the soft tissues, and the blackening around, will vary according to the circumference of the cone of the propelled gas which is first forced against them, or, in other words, within the limits above-named, according to the distance from the wounded part at which the rifle has been discharged.

Wounds from bullets with somewhat lessened speed.—When the rifle has been discharged further off, at a distance of two or three hundred yards for example, the early appearances of the wound of entrance made by the bullet are different from those just described. An opening about the size of the projectile, but not unfrequently appearing rather smaller, is now to be observed. It is generally circular in shape, but sometimes more elongated in one direction than in the other, with the edges a little serrated, undermined, puckered, and flabby. Occasionally a single flap of integument is found at the opening, held by a small isthmus of skin to a part of its margin; sometimes the opening is bounded by two or three loose flaps, which, on being lifted up, approach at their free ends towards its centre. With both the spherical and the cylindro-conoidal bullet, when they are travelling at a very high rate of speed, and strike point blank, not obliquely, the opening consists of a vacant circular space, corresponding with the circumference of the projectile, and representing the site of a portion of integument which has been carried away by the bullet. With a certain amount of diminution of speed in the two bullets, there will be less loss of substance with the conoidal than with the round bullet; and if the speed be still further diminished, though still sufficient for the two bullets to penetrate, and pass deeply into a part of the body, there will apparently be no loss of substance with the conoidal bullet, but the opening will be formed simply by division and separation of the edges of the rent skin, while with the round bullet there will still be a portion of skin carried away before it. In each of the forms of opening above-named, the whole wound presents a slightly inverted aspect. There may be darkening of the marginal skin of a livid purple tinge from the effects of destructive contusion, increased in depth of colour sometimes by dislodgement of a little unexploded gunpowder which had been adhering to the bullet; while occasionally the edges of the wound will appear flaccid and pale, as if the bullet, at the same

time that it deprived them of vitality, had also pressed out all the blood from their capillaries. The margin of the opening, again, will be surrounded by a violet-coloured marking of the neighbouring skin, varying in depth of tint and extent according to the amount of contusion. Outside this again will usually be a bright pink blush indicative of capillary injection. The evidences of contusion are always most marked at the wound of entrance, when there are two openings. The peculiar appearances of the contusion surrounding the opening of a bullet wound, the extremely severe contusion of the lips of the wound, with the regular gradation of diffused tint as it shades off into the healthy skin beyond the sphere of influence of the projectile, are very characteristic of the injury, and readily distinguish it from a contused wound inflicted by an ordinary blunt instrument.

The following appears to be the explanation of the different conditions which result from the penetration of spherical and conical bullets.

With a spherical bullet at its highest rate of speed, a cap of integument closely corresponding in dimensions with the front of the bullet up to its equatorial limits is at once cut out and carried away before the bullet. With less speed only a smaller segment of the bullet exerts this concentrated punching out force on the skin immediately opposed to it. The rest of the face of the bullet, acting more and more obliquely until its equatorial circumference is reached, stretches the skin before it so as to form a cup-like depression, within which the ball glides onwards: at the same time slightly tearing and distending the edges of the hole, whence the part had been punched out, sufficiently to permit the whole projectile to pass through to the deeper structures. If the skin impinged upon happen to be so placed as to be capable of exerting its elastic quality evenly on all sides, the margin of the hole is left entire, though probably devitalised by the severe stretching and contusion to which it has been subjected. If, on the other hand, the skin happen not to be free, but is intimately connected with neighbouring fascia, then the margin of the hole will probably be left with a torn fringe, or be divided with flaps.

With a conically-pointed ball a similar action takes place, but the opening left is necessarily smaller, owing to the obliquity of the surface presented to the skin being greater, and the diameter of the elongated bullet being less. No skin may be carried away when the speed is much diminished, because time is given for the opening to be made by stretching and tearing asunder the opposing tissues.

Wound of exit.—Should the bullet have passed out, the wound of exit will probably be larger than the projectile, sometimes much larger, but generally with little or no actual loss of substance. It will be more irregular and torn than the wound of

entrance, with eversion of its edges, and occasionally, at the margin, protrusion of particles of subcutaneous fat, or deeper tissues.

Different appearances of wounds of entrance and exit.—The differences between the appearances presented by the openings of entrance and exit to whatever extent they may be exhibited, are the more easily recognised the earlier the wound is examined. They are due partly to the velocity of the bullet having been somewhat lessened by the opposition it has met with while passing through the several structures which it has successively traversed; partly to the structures at the place of exit having been forced *away from* their supports instead of *towards them*, as was the case at the wound of entrance. They are more obvious if a round musket ball has caused the injury than when it has been inflicted by a cylindro-conoidal bullet: indeed, with the latter, when it has passed apex forwards in a direct line through the soft tissues of an extremity of the body at full speed; when, therefore, there is scarcely any difference between its rate of movement on going out of the body as compared with its rate of movement on entering; when it has neither carried a foreign body nor a fragment of bone or any other internal substance before it; under these circumstances it is often very difficult to distinguish the wound of entrance from that of exit by their respective appearances or sizes even in the early condition of the injury.

When the wound of exit of an elongated bullet, which has only traversed soft tissues, is much larger than that of entrance, it will generally be found that other substances besides the bullet have been carried through it. Thus, in one example at Netley of a wound of the abdomen by a chassepôt bullet, with a very large opening of exit, some omentum has passed out with the projectile. As a general rule, however, where soft parts only have been pulpified by an elongated bullet, however wide the cone of injury within, the elastic skin is able to keep nearly all, excepting the bullet itself, from passing through it.

Circumstances which modify the appearances of wounds of entrance.—The position and state of the skin at the moment of being opened by a projectile will sometimes modify the appearance and size of the wound of entrance. If the integument belong to a part where soft tissues abound, and where it is subjected to occasional distension and relaxation, and the projectile strike the surface at the time the integument is on the stretch with only a moderate penetrating force, then the opening will appear very small with reference to the projectile in the relaxed state which the parts will assume shortly after the infliction of the injury. The opening will appear to be still smaller after infiltration and swelling of the surrounding tissues have occurred. A similar projectile, if it impinged upon skin overlying bone, as one of the ribs, would cause a far more extended wound of irregular outline,

for the skin would be crushed and the elasticity of its edges impaired between the direct impact of the bullet on the one side and the resistance of the bone beneath on the other. If, on the other hand, it happen to strike and penetrate between two ribs, the direction in which the skin becomes stretched, owing to its position before yielding for the passage of the bullet, may cause the wound of entrance to assume the character of a slit or fissure running parallel with the ribs above and below.

Later appearances of gunshot flesh wounds.—As soon as inflammation and its attendant swelling and vascular excitement have supervened, the appearances will of course no longer agree in all particulars with those which have just been described; and if the wound be examined a week or so after its infliction, especially when the bullet has struck with an average amount of force, not at its highest rate of velocity, and when it has passed out unaltered in form, the appearances described as characterising the wounds of exit and entrance will frequently be found reversed. The different features presented at these two periods of time have probably led to some of the discrepancies in the descriptions of different observers of the relative sizes of the two openings. The wound of entrance will at this latter date appear to be the larger, and there will probably be more protrusion from it than at the wound of exit. The tissues which first received the stroke of the bullet, and which were, therefore, most extensively contused and deprived of vitality, are now being cast off in a sloughy condition; the tissues through which the bullet last passed, and which were, therefore, least injured, are now assuming a clean and healthy aspect.

Conditions upon which the diagnostic signs above mentioned depend.—The description above given refers to the appearances presented when a bullet enters alone, without any portion of clothes or other substance being carried in front of it, and when it preserves its shape throughout its course in the wounded part. Should some extraneous substance enter with the bullet, the appearance of the wound of entrance and its relation to that of exit will be changed in certain respects, as will be noticed presently. Should the bullet after entering become spread out or otherwise altered in form, as often happens when it strikes against and glances over a strong resisting bone, the general conditions as described will still exist, but obviously the relative magnitude of the wound of exit will be increased in proportion to the increase of dimensions which has taken place in the projectile itself.

Wounds from shrapnell bullets.—The wounds inflicted by hardened bullets from shrapnell or canister differ in no respect in their nature or appearances from wounds produced by musket shot of nearly similar sizes and weight; but, owing to the less velocity of the shot at starting, the wounds are not often so severe as those from fire-arm projectiles. Soldiers wounded by such bullets are

usually struck by them after much of their momentum is expended, so that they seldom have force enough to make a wound of exit.

Appearance of a bullet wound with fracture of bone.—If the bullet, instead of causing a simple flesh wound, should meet and fracture a bone in its passage, especially if the fractured bone is situated near to the surface towards which the projectile has taken its course, and is not covered very deeply by the muscular tissues, then the wound of exit differs greatly in appearance from the wound of entrance. It no longer corresponds in general outline with that of the bullet, but presents flaps of irregularly torn skin and subcutaneous tissue, the length, number, and direction of the rents varying according to the shapes and number of the splinters which the bullet has thrust forward and pushed aside as it forced its way out from among them. The bullet, too, under these circumstances, is probably considerably flattened and altered in shape, or is broken into two or more fragments, and thus adds to the difference in character between the wounds of entrance and of exit. Although the appearances just described apply generally to all gunshot wounds complicated with fracture of bone, there are some special peculiarities in the appearances of certain wounds, in which particular bones are involved, such as the ribs, the bones of the cranium and others, but these can only be properly discussed when the injuries of the particular regions in which the bones are situated are considered.

Wound of entrance larger than the wound of exit immediately after the injury.—There are occasional cases where the wound of entrance is larger than the wound of exit directly after the bullet has passed through a part of the body. Sometimes it appears to be so when it is not truly larger. It may be really so if the weapon has been discharged so close to the person that wadding, or any other substance contained in the fire-arm, has been carried into the entrance wound with the bullet; or if the projectile, on entering, carries before it a portion of some of the coverings of the person wounded, such as a piece of leather or cloth, and then passes out without carrying before it either this additional substance or any portion of the tissues through which it has cleft its way. The same conditions will also occasionally be found to exist when the bullet has entered a part of the body where the integument covers a superficially placed bone, and when, coursing afterwards through muscular tissues, it makes its exit at some part remote from the place of entrance. Thus a bullet entering over the olecranon and passing out in front of the upper part of the arm, or entering over the malar bone and passing out through the soft parts of the back of the neck, will present a larger wound of entrance than of exit. But, very frequently, the wound of entrance is only larger than that of exit in seeming; and this is owing to the projectile having struck the surface slantingly, so that parts

of the skin and subcutaneous areolar tissues have been shaved away, as it were, before the projectile has passed inwards through the superficial fascia. There is here, strictly speaking, a rasing wound on one side of the true wound of entrance; for the true entrance wound is, of course, the commencement of the track of the projectile through the deeper structures. A wound of this kind leaves a peculiar scar, in which the difference between the superficial injury, the rasing wound and the seat of the aperture of entrance is always very strongly marked.

In medico-legal investigations concerning gunshot wounds, it sometimes is still a matter of great importance to decide which of two wounds made by a projectile has been the entrance wound, and the evidence of surgeons is often closely sifted in courts of law on this point; but to military surgeons, more especially from circumstances connected with the new projectiles, it has become a subject of much less practical interest than it formerly was. When the indirect and tortuous penetration of bullets was the rule rather than the exception, a knowledge of the spot at which a bullet entered was often useful in diagnosing the mischief it had probably committed in its passage, and in determining the part of the wound where foreign substances might be supposed to be carried and to be lodging. When the track of the bullet is nearly in a straight line, as now so frequently happens, such information cannot be looked for from knowing the relation of either opening to the course of the projectile.

Bullets striking the surface with a parallel or very oblique direction.—The appearances above described, as already mentioned, are those produced by bullets when they are brought into collision perpendicularly, or nearly so, to the surface wounded. When, however, they strike at an acute angle, the extent and appearances of the wound may vary very greatly. If the bullet touch or strike while passing in a direction almost parallel with the surface, constituting what is termed a 'rasing shot,' [2] the wound may have the appearance as if a line of integument of the width of the projectile had been planed off. If it penetrate more deeply, a furrowed excavation, rendered broader than the width of the projectile by the elasticity of neighbouring structures, may be presented to view. The length of the wound in either case will depend upon the character of outline of the surface with which the bullet has been brought into collision; being short if it happen to have struck the surface of a part with very convex outline, longer according as the surface approaches nearer to a level. As in other gunshot wounds, the edges are more or less irregularly torn, and more or less extensively ecchymosed and livid, according to the velocity with which the bullet has traversed the substance of the rased structures.

If the bullet strike a little deeper than the surface, and in such a way that a portion of integument is momentarily forced up

in front of it, instead of the open furrow, a tunnel-like wound, with a thin covering of integument over it, may be inflicted. The appearance of the integument covering the tunnelled opening varies according to the depth of subjacent tissue, but is usually left pale and livid, very quickly, however, exhibiting alterations in colour and condition from the effects of inflammatory action.

Varieties in number of openings made by bullets.—The *number of openings* made in the body by one, or any other given number of small projectiles, is subject to several variations.

Number of openings usually made by bullets.—A bullet ordinarily causes either one wound, as when, after entering, it lodges, or, as sometimes though rarely happens, when it escapes again by the wound of entrance; or else it causes two wounds, one being the opening of entrance, and the other that of exit of the projectile.

Wounds caused by a single projectile.—It is not always easy to decide at first sight on two wounds being presented to a surgeon's notice, whether they are really the wounds of entrance and exit of one and the same projectile, or whether both are entrance wounds caused by two distinct projectiles. The openings made by a single bullet may hold such a relative situation to each other, be placed so wide apart, and seem to have so little connection one with the other, as to lead to the mistaken supposition that they have been caused by distinct projectiles; and careful observation may be necessary to establish the true diagnosis or to prevent needless and hurtful search after bullets where none are lodged. The following case, which occurred in the Crimea, will serve as an illustration. A bullet entered the scrotum, took a deep course, and made its exit from the back of the right thigh, without any superficial intermediate marks to indicate its true track. Here, from the want of apparent connection between the two openings, the conclusion was at first come to that two projectiles had entered, one at the thigh, the other at the scrotum, and that both had lodged. Search was made for them, of course without effect. Subsequent events showed both wounds had been produced by one and the same bullet. The length of the traverse of a bullet, and the consequent distance between the openings of entrance and exit; the fact of parts of the body being brought into unusual relations with each other due to peculiarities of posture at the time of being hit; or of a bullet being subjected to a special deflection after entering the body; all these may be sources of a similar error in the early diagnosis.

Single bullets sometimes make more than two openings.—Surgeons must be prepared to find occasionally a greater number of openings, and more than one wounded track in the body, from a single bullet. This may happen in several ways; and it may occur both from bullets that have remained entire, as well as from bullets that have been broken into two or more fragments.

Multiple wounds—bullet remaining entire.—With a bullet remaining entire, the number of wounds may be increased by the projectile traversing two or more adjoining parts of the same person. A soldier of the 55th Regiment was wounded in the Crimea by a musket bullet, which entered between the glans penis and prepuce, ran beneath the skin without opening the erectile tissue, made exit at the root of the penis, passed into and through the scrotum, entered the thigh, and, finally, was cut out of the buttock. Five apertures were here made by the bullet, without counting the one for its extraction. I have seen an officer, in whose case a bullet passed through the forearm, arm, and side, making six openings in its passage. Here the forearm was bent upon the arm, which, again, was in close contact with the trunk, the wounded parts being thus in close relationship with each other. Occasionally distant and very unconnected parts of the body are wounded by the same bullet, owing to some accidental relative position at the time of injury. A bullet has been known to strike the right arm above the elbow, causing a comminuted fracture of the humerus, and then to pass in front of the man's trunk, and enter the left arm below the elbow, fracturing the upper part of the radius. Dr. Hennen mentions the case of a man on a sealing ladder, in which a ball passed from the middle of the upper arm on one side to the middle of the thigh on the opposite side. It is evident, when bullets travel with sufficient velocity, that such accidents as these will not unfrequently occur, especially between one of the upper extremities and the trunk and between the two lower extremities. They correspond with such events as more than one person being wounded by the same bullet, examples of which were not unfrequently noticed in the Crimea. They are also recorded to have been common in recent Continental wars.

Multiple wounds—bullet divided.—With a divided bullet, when the division has occurred from the missile being split within the body, each fragment may cause a wound in a different direction. In this way the division of a bullet may not only increase the number of wounds of exit contiguous to the part first wounded, but also may cause fresh wounds of entrance in some other adjoining part. Thus a bullet has been known to enter the thigh on one side, to become split into two parts against the femur, and, after traversing the inner aspect of the same thigh in two directions, to enter the corresponding aspect of the opposite thigh at two points,—one ball thus causing five orifices, two of them being wounds of exit and three being wounds of entrance. The same effect may result from the bullet being divided by coming into collision with some hard narrow ridge of bone *near the surface of the body*, or the sharp edge of a bone after it has been fractured. Many examples occur of the division of leaden bullets into two or more parts, from striking against the spine of the tibia, the supra-

orbital ridge, the clavicles, or against edges of fractured cranium, lower maxilla, and other bones. This occurrence has even taken place from a bullet impinging against the narrow margin of the semi-cartilaginous vomer. On such an accident taking place the divided parts of the bullet naturally diverge and pursue their courses in different directions, so that the instances of single projectiles in this way leading to several wounded tracks within the body, and either causing lodgement of foreign bodies in different situations, or making several wounds of exit, are by no means uncommon.

Multiple wounds—more than one wound of entrance.—In the instances just mentioned the original wound is a single one, whatever may be the number of wounded tracks or openings afterwards effected, but sometimes there is even more than one original wound of entrance, owing to some accident happening to a projectile just before striking the body. Soldiers have been wounded in several places from bullets having been divided into two or more portions by striking against a neighbouring rock or wall, or against stones on the ground a few paces in front of them, the fragments rebounding or glancing off at various angles, and still preserving force enough to penetrate the men with whom they have afterwards come into collision.

Less wounds than projectiles.—On the other hand, though happening much more rarely, the wounds may be less in number than the projectiles which have been employed to inflict them. Several cases have come under my notice among men invalided for the effects of gunshot wounds from whom two bullets have been extracted, though only one wound of entrance had been inflicted. John Hunter has recorded the case of a gentleman who was shot by a musket loaded with three balls. In this instance there were only two orifices of entrance and two of exit, one ball having followed in the track of another; 'that there were three that went through him, was evident, for they afterwards made three holes in the wainscot behind him, but two were very near each other.' In the Pathological Museum at Netley there is a preparation of a femur taken from a soldier wounded in the Crimea, showing a fracture, the cure of which was prevented by the fact of two balls having entered by one wound, and the lodgement of the second at the seat of fracture having been undetected. When muzzle-loading muskets were in use it frequently happened under the excitement of action that men, surrounded by the noise of musketry discharges, thought they had fired off their weapons when really they had not done so. Hence, double loading was no uncommon occurrence, and the chance of more than one bullet entering by the same opening at short distances was proportionably greater. Even when the bullets are fired from different weapons the same accident may occur. It was stated, in the instance of a

soldier who was shot for desertion and other crimes during the United States' war, that there were only eight entrance openings, although examination showed ten bullets had passed through the prisoner's body. Four of the bullets had passed through two of these openings.

CHAPTER II.

CHARACTERISTIC FEATURES OF INJURIES FROM PROJECTILES OF A GASEOUS FORM.

Conditions which modify the characters of injuries from gaseous projectiles.—The characters of bodily injuries produced by gaseous projectiles vary much more according to the manner in which the gas is directed against the body and the part of it which is struck, and these variations take place in a far more rapid ratio within limited distances, than do those of injuries produced by solid or liquid projectiles. This is manifestly due to the great rapidity with which these elastic substances quit the diminished volume under which they at first exist, and to the rapid loss of elastic energy and propulsive force that takes place in proportion as the change is accomplished. The volume of gas resulting from the discharge of a blank cartridge from a musket, the muzzle of which is placed in the mouth of a suicide, will tear the brain in pieces and separate all the bones of the cranium from its sutures; at the distance of a few yards the same discharge will inflict little more than a slight contusion; at a few yards further off nothing will be perceived but the impulse given to the surrounding air by it. The degree of severity of the injuries resulting from gaseous projectiles, and the distances at which they may be inflicted, greatly depend also upon the amount of gas, or in other words the dimensions of the volumes of gas, of which the original gaseous projectiles are constituted.

Wounds by gaseous projectiles.—The impulsive force of discharged gaseous substances is manifested in the production not merely of contusions but also of the severest wounds when circumstances are suitable. Such wounds usually exhibit a markedly lacerated and contused character, and are very irregular in outline. If clothes are worn over the wounded part they are torn asunder, or may be so caught by the gas as to be carried away altogether—'blown off.'

Wounds from concentrated volumes of gas.—If a musket be discharged close to the head of a person, but yet in such a position that the bullet and other solid contents of the charge pass away without striking it, the surface near to which the muzzle of the fire-

arm was placed will probably be found bared and the scalp irregularly lacerated. The scalp may be torn up in shreds several inches in length, in consequence of the force with which the gas propelled from the fire-arm has passed on between the bone and its covering; the latter being stretched to its extreme limit, and then rent asunder. Corresponding results will ensue whatever part of the body may be exposed to a concentrated gaseous discharge directed against it in a similar way. When the volume of gas is greatly increased, as when a large gun is fired with blank cartridge, if a limb of a person be exposed to the stroke of the emitted gas it will be torn from the body, or if the whole body be exposed to the discharge, shortly after its emission from the muzzle of the piece, it will be torn asunder into fragments, and its portions driven to long distances through the air. Many terrible examples of this fact were afforded in 'blowing away' men from guns at the time of the great Sepoy Mutiny in India.

Injuries from gas of less tension.—With a similarly large volume of gas, if the person exposed to its impact be at a moderate distance off from the point of discharge, the injuries produced will be general concussion and contusion, and not an open wound. There will frequently be the usual evidences of local contusion and of muscular strains in the parts most exposed to the blow, but external signs of injury are generally absent.

Injuries from the gas of exploded shells.—Examples of injuries of the severest nature occur from time to time in warfare in consequence of the bursting of a shell close to a soldier, when none of the fragments have come into collision with the injured man's body. Soldiers soon learn in warfare, almost instinctively, in case of a live shell falling near them with its fuze burning, and of there being no time for escape by flight nor means of getting cover, that their chief chance of avoiding destruction consists in throwing themselves flat on the ground. Under such circumstances, if the shell happen to burst near the head of one of the prostrate men, the brain and medulla oblongata will most probably exhibit signs of serious injury, though no visible wound is inflicted; or, if it burst so that the force of the explosion is urged against the chest or abdomen, the violent agitation of some of the viscera contained in the cavities of these regions will almost invariably lead to grave and not unfrequently fatal results. Mr. Erichsen has mentioned a case in which the muzzle of a pistol charged with powder alone was fired against the chest of a man, when death, from concussion of the heart, was the consequence.[3]

Similar accidents, though they do not happen so frequently because the same timely warning is not given to enable men standing near to throw themselves upon the ground, occur with modern percussion shells. On such shells bursting, the men close by who escape being struck by their fragments often suffer from sharp con-

tusions about the legs. They are not placed in the same danger from this source as men lying on the ground, for the force of the exploded gunpowder naturally becomes considerably lessened in intensity before it can reach the vital parts of the body.

The contusion from the gas seems to produce in some of the cases just mentioned a vibratory disturbance of the internal organs near to the surface on which the impact of the projected gas is directly received. The fact of the force of the vibrations varying in intensity will cause proportionate differences in the amount of the resulting lesions in the organs concerned. In slight cases the effects will pass off comparatively quickly; in severe cases serious impairment of their functions may last for years. Not even a bruise of the surface will probably be perceived; perhaps no lesion internally would be apparent were the opportunity of observation presented. If the force of the impact be directed against the head or back of the neck, any of the usual consequences of cerebral or spinal lesions may be presented—paralysis, more or less marked, of sensation or of motion, or other disordered conditions of the nerve functions.

Injuries to mental faculties from gaseous projectiles.—Mental faculties are apt to be more or less weakened by the impact of gaseous projectiles in concentrated volume, and one very common feature presented in all such cases is not merely a diminution in power of some of the intellectual faculties, but an irresolution of purpose and a degree of timidity which may be altogether foreign to the previous characters of the individuals concerned. It is very important to bear in mind in such cases that these alterations of character are due to physical changes, the result of the injuries to which the patients have been subjected. Medical officers, by duly weighing these circumstances, may often be the means not merely of saving officers and soldiers from obloquy which they do not deserve, but also of helping them towards obtaining the compensation to which they are justly entitled, not alone for the bodily harm which they have sustained, but also for the moral deterioration which has been inflicted upon them entirely from the public service, and not from any private fault. These cases are analogous in their nature to cases of concussion which occasionally result from railway injuries when no external wounds or damage are presented, and the patients are as much entitled to compensation for them, when their nature is properly established, as they would be for other injuries.

Injuries to the organs of hearing and sight.—Two of the organs of special sense, the ear and the eye, are often materially injured by the effects of explosions, but more especially the former, as might be anticipated from the nature of its function. Injuries to the organ of hearing from the concussion resulting from discharges of fire-arms frequently come under the notice of military

surgeons. The violence with which the column of gas is forced against the membrana tympani is liable to rupture it, and the excessive concussion of the auditory nerve is often sufficient to paralyse, or even to destroy, its function. The severity of the injury depends not only upon the intensity of the stroke, and upon the relative position of the soldier to the undulations of emitted gas, or of air set in motion by the gas, but seems to be greatly modified according as the sufferer's ear is prepared or not for receiving the blow. Some of the effects of this source of concussion were well exemplified in the instance of my friend, Lieut.-Colonel H. Brackenbury, R.A., who was struck during the siege of Paris by a column of gas emitted from the exploded charge of a shell. I cannot do better than use Colonel Brackenbury's own account of the injury written in a letter to me not long after its occurrence. 'On Tuesday, April the 25th, I was in No. 1 Battery on the plateau of Chatillon, under a heavy fire from the fort of Vanves. Two guns were already dismounted. The embrasures opposite the two remaining guns were blinded by gabions. I was looking out with my field-glass between the gabion and cheek of one of these embrasures, when warning was given of a shell coming. I stepped away, and placed my back against the merlon, close beside the embrasure. A heavy shell came in through the embrasure, knocking the gabion to pieces, and burst on the gun wheel about three feet from, and to the front of, my right side, dismounting the gun. I felt such severe pain in my right ear, that I thought I was wounded, and said, "*Ça m'a cassé l'oreille.*" But I was not hit. The right side of my face swelled up, and I was deaf on that side for a considerable time. The muscles of the neck also gave me some pain. Ten days afterwards the pain in my ear suddenly grew sharper, and an abscess burst in it, followed four days later by a second. I then got rapidly better, and am now well; though sometimes both ears seem dull, and ache a little.'

When the face of a person is turned towards the focus of an explosion, and he is standing near enough to be violently concussed by the movement of the impelled gas and air, his power of vision is not unlikely to be injured. The mischief done for the most part is only of a temporary character, but occasionally sight is permanently destroyed. In many of these cases the injury to the eyes is of a mixed nature, the lesion not being entirely produced by the concussion, but being also partly due to the scorching effects of the flash of flame accompanying the explosion, or to the impact, or penetration, of solid bodies, such as grains of gunpowder, sand, and gravel, or other substances. But in other cases the loss of vision is due solely to the effects of the contusion and concussion resulting from the impact of the volume of gas. Thus in the history of the Crimean War it is specially mentioned in one instance, in which blindness followed exposure to a magazine ex-

plosion, that the blindness was not attributable to collision with any solid body, but was due to the direct force of the concussion. In this case the eyeballs remained full, and retained their natural rotundity, and the only alteration noticed was a bluish-white opacity of the whole of each cornea, which took place within a few hours of the receipt of the injury. This appearance was attributed not to the flame having reached the eye, but to part of the aqueous humour having been forced between the layers of the cornea. The amount of inflammatory action which followed was very slight, but vision was completely and permanently destroyed, probably by concussion of the optic nerves.[4] Mr. MacCormac, in his 'Notes of an Ambulance Surgeon,' refers to a case that came under his notice at Sedan, of 'temporary loss of vision from a shell explosion close by, which caused no further injury.'[5] Even the explosion of the comparatively small quantity of powder which is contained in a common musket may produce the same serious consequences, if favourably directed for inflicting a sudden forcible compression of the organs of vision. A soldier of the 68th Regiment had the sight of both eyes destroyed in the trenches before Sebastopol by the concussion resulting from the explosion of an enemy's musket close to his face; the ball passed without injuring him.[6]

Effects of magazine explosions.—But the most terrible effects of explosions are witnessed in instances of accidental ignition of large stores of gunpowder contained in magazines, whether in those collected for the service of the batteries in siege operations, or in the still larger magazines of reserve supplies in rear of the trenches, in arsenals, and elsewhere. Catastrophes of this kind are not unfrequent occurrences in connection with military operations. Several such occurred during the Crimean campaign. The most extensive which took place, and probably the most formidable one that has ever occurred in warfare, was the explosion of the magazines of gunpowder and munitions of war in the French siege park and the adjoining English siege train enclosure, on the 15th of November, 1855. According to Dr. Chenu,[7] the magazines which exploded in the French park contained 50,000 kilogrammes of powder, 4,000 large projectiles and rockets, and 600,000 small-arm cartridges; while the losses among the troops were 4 officers killed and 11 wounded; 16 sub-officers and soldiers killed, 13 disappeared, and 103 wounded.[8] A Divisional Field Hospital near the scene of the explosion was destroyed, and six medical officers were wounded. On the English side, chiefly in the regiments of the Light Division, and in the Right Siege Train, 1 officer and 20 non-commissioned officers and men were killed, while 4 officers and 115 non-commissioned officers and men were wounded.[9] The extent to which projectiles were scattered by the explosion is shown by the fact that the casualties occurred in the camps of no less than fourteen regiments. In some instances the bodies of men were so torn asunder and muti-

lated, and the detached parts scattered to such distances in different directions, by the force of the explosion, that collocation of the parts belonging to each other was impossible. Dr. Chenu accounts for the French 'disappeared' by suggesting that some of the victims of the explosion were buried under the ruins, and not found again. As the flame of the explosion set fire to the adjoining huts and tents, the remains of some of the missing were probably lost in this fire.

The numbers above given comprised those who were actually killed by the force of the explosion itself and those who were killed and wounded by the solid substances which were projected by it in every direction. Some men were also wounded through the bursting of ignited shells. But, in addition to the casualties enumerated in those statistics, there were large numbers who, though not struck by any solid projectile, nor visibly wounded by the impulsive force of the explosion, were yet more or less seriously contused and injured by it. Some suffered from rupture of superficial blood-vessels of the air-passages and lungs, others from mischief to the organ of hearing. Especially prevalent, however, was shock to the general nervous system, and there could be little doubt, from observation, that this was not merely the result of panic but was largely due to actual physical concussion and contusion.

At the time of the explosion I was sitting alone in a small stone hut on the extreme right flank of the First Brigade of the Light Division, about five hundred yards in a direct line from the Parc de Siége where the explosion occurred. A shower of projectiles fell about the hut, and among others, a shell of large size burst immediately over the roof, as was afterwards proved by its fragments being found close to the walls on the two opposite sides of the hut. The roof of the hut was twisted partly round, and a small skylight, by which the interior was lighted, and which was just above the table at which I was then writing, was blown in. I myself was knocked off the stool on which I was sitting down to the floor, without, however, being touched by any solid substance, and for the instant was deprived of consciousness. I judged that I could only have been a few moments in this condition, for, on getting to the door, which I seemed to have done with the intention of escaping, but at the same time almost automatically, numerous projectiles were still bursting in the air and on the ground, and drove me back. The earliest impression which I found on my mind on consciousness returning was that a mine had been sprung by the Russians beneath us,—a notion momentarily entertained by others as I afterwards learned—and no doubt this feeling got its origin in the trembling of the ground which immediately followed the explosion. Anyone who has experienced the agitation of frame which is produced by the wave movement of the

floor of a building, or of the ground itself during the progress of a severe earthquake, will readily comprehend the influence which would be exerted by the movement of the ground that took place from the concussion to which it had been subjected on this occasion. This movement was not noted by myself, but was by many others; the fall, and the temporary stupor to which I was subjected, probably deprived me of the power of observing it. When, shortly afterwards, I left my hut to make my way to the hospital, one of the first men I met was a strong powerfully framed artilleryman belonging to the Right Siege Train who had been rendered suddenly fatuous by the explosion. He was not paralysed, for he was being brought along walking, though with an unsteady gait, and the peculiar vacant expression of idiocy. I stopped the two men who were leading him along, and hurriedly examined him. There were no marks of injury upon the poor fellow's body; but his intellectual faculties seemed to have been completely obliterated by the shock to which he had been subjected, and the impression on my mind was that they had gone past recovery.

On afterwards considering the event, as regarded myself, it appeared to me that the shock from the explosion was too instantaneous for fear to have had any part in the effects it produced. The intensity of mental surprise at suddenly hearing so immense a volume of sound, and at feeling simultaneously the shock to the whole system, both happening at a moment when mind and body were totally unprepared for the occurrence, no doubt had an important influence; but what the amount of this influence was, as compared with the amount due to physical agitation of the frame from aerial impulse, it is difficult to decide. I am inclined to attribute the greater part of the effects—the temporary paralysed condition of body, and the accompanying stupor of mind—to the disturbance of the brain and nerve-centres by the actual molecular agitation produced by the violent impulse of the air; and to regard the time occupied in the return of perception and of voluntary power as indicative of the time taken by the shaken structures in recovering their balance which had been so suddenly interfered with. And this seems to be borne out by the fact that the nearer to the centre of impulse, and, therefore, the more violent the force of percussion from the detonation, the greater in amount, and the more persistent the disturbance usually is, and the slower the recovery.

The shock from explosions modified by habit.—One peculiarity connected with the shock and other symptoms produced by explosions, is the extent to which these effects are modified by the influence of habit. Artillerymen are affected in various ways when they are first trained to the use of heavy guns, especially when they are fired on ship-board, in casemates, and under other circumstances in which there is much reverberation from the gases evolved not

having means of free escape into the surrounding atmosphere. But these effects gradually pass away with practice and custom, if men are in a vigorous state of health.

I was at one time in a station in the West Indies where the morning and evening gun, the report of which was audible at many miles' distance, was fired close below the mess-room in which I with other officers dined. Persons and articles of furniture in the apartment were shaken every time the discharge took place. Yet, after being accustomed to the occurrence, the firing of the gun often passed so unnoticed that the question was not unfrequently asked whether the gun had, or had not, been fired. The vibratory agitation of the air, and the sound of the heaviest bombardments of Sebastopol, made less impression upon those who had become familiar with the effects of the constant cannonading from long residence close to the siege works, than the cessation of it did after the place fell. For a few days after this event the great change to continuous silence, and to comparative stillness of the atmosphere, was as painful to those who had been long accustomed to the siege operations, as agitation of the air and the roar of a heavy bombardment had been to new comers. The influence of custom in modifying the disturbance to particular organs, and the effects of the general shock to the body, produced by the concussion of the air resulting from explosions, is one of not the least curious circumstances connected with this subject. When men are depressed in general health, and debilitated, or are suffering locally from the effects of injury or disease, the favourable effects of habit in the respects mentioned are not so manifest; on the contrary, increased irritation is often excited, and it is necessary for the patient's recovery that he should be removed from the sphere of agitation to which repeated discharges of cannon subject him.

The particular local effects of explosions on special organs, such as that of hearing, vision, and others, can be best studied when injuries of the regions to which the organs belong are under consideration.

Injuries from fougasses and torpedoes.—Injuries resulting from the action of exploded gases on the feet, legs, and lower parts of the bodies of soldiers are met with from other causes besides the explosion of shells. They are especially liable to be met with on the occasion of an assault when fougasses are employed in the defence of a besieged place. The soldier by whose weight in walking a fougass is exploded, can scarcely escape from the effects of the rush of the pent-up gas, even if he happen not to be struck by the stones, fragments, and other miscellaneous missiles projected by the explosion. The effects are shown in terribly severe injuries. Sometimes grave, deeply-seated mischief occurs, such as comminuted fractures of the bones of the foot and leg, rending and

pulpification of internal tissues, leading to gangrene as a necessary consequence, without visible lesion of the superjacent integuments; sometimes extensive mutilation and separation of soft parts, with tearing asunder of the tarsal bones, and fractures higher up the limbs may be observed; sometimes parts of the feet and legs are blown away altogether, with laceration and destruction of the vitality of the structures for some distance above the site of separation. These injuries, as might be expected, are complicated in numerous instances with burns from the flame emitted at the moment of explosion, as well as with wounds from the various missiles projected by such machines; but even when unaccompanied by these complications, the mischief done by the force of the exploded gas upon anyone who happens to be within the immediate sphere of its influence is almost always so great as to necessitate amputation of portions of one or both lower extremities. Exceptions do, however, occur. Two men of the 97th Regiment trod upon fougasses in front of the Redan, after the place had fallen, and had only their trousers torn off, with slight scorching of their limbs by the flame of the explosion; they escaped without any deep lesion. In the instances of soldiers who have been killed on the spot by fougass or torpedo explosions, some injury to the trunk by solid projectiles has probably occurred.

CHAPTER III.

CHARACTERISTIC FEATURES OF THE INTERNAL TRACKS LEFT BY BULLETS IN DIFFERENT PARTS OF THE BODY.

Shape and dimensions of a bullet track.—When a digital examination is made of the track left by a bullet which has passed in a direct line through a fleshy part of the body or one of the extremities, it is often a matter of surprise how irregular it is in its dimensions and shape. Instead of a regular conduit or canal of even calibre, which it might be supposed the traverse of a bullet would leave, somewhat resembling in shape and size the barrel of the gun through which the projectile had been forced at the time of its discharge, a hollow wound is felt, constricted at one part, free and expanded at another, and deviating here and there in various directions from a straight rectilineal path. The finger finds substances opposing its direct passage onwards, which it must displace in order to continue its further progress, and these substances present to the touch different conditions and degrees of resistance.

It is only necessary to call to mind the varied anatomical structures which enter into the composition of a given part of the body; their different physical qualities as regards texture, elasti-

city, form, and power of resistance; their mutual relations, particularly in regard to fixity or looseness of position, and their modes of connection one with another, to understand why such irregularities should be found in the tracks left by bullets. At the same time it is necessary to remember that the speed with which the bullet traverses these structures, and some of the physical qualities of the projectile itself, more particularly its shape and diameter, materially influence the extent to which the special qualities of the structures traversed can be exerted. As a general rule, when a bullet maintains its direct course, the higher the rate of speed and the more obtuse the front of the projectile, the more direct is the track, and the more complete is the destruction of all the parts opposed to its passage, whatever their nature; and, consequently, the less the alteration in the size and shape of the track for a certain time after the bullet has passed.

The following may be regarded as the general characteristics of the wounds made in the several anatomical structures through which a bullet travelling in its regular line of flight has effected a passage. The characters of the wounds become materially altered in respect to shape, size, and amount of laceration, if the projectile has been caused to traverse the tissues in any other than its normal line of flight; as when an elongated bullet has been caused to traverse them while rotating on one of its short axes, for example, instead of its long axis. Some of the effects of such accidental alterations in the manner of flight of bullets upon wounds have been already noticed when the subject of the dimensions of bullets was under consideration in the preceding section of this work.

Bullet openings in fascia.—Presuming that a bullet has inflicted a flesh wound through one of the extremities, the thigh for example, while maintaining its ordinary mode of flight, and retaining an average rate of speed, the first part of the track will usually feel constricted as compared with the parts beyond. This may sometimes be due to contraction of the opening through the skin and superficial fascia, but is more generally the result of the peculiar opening through the aponeurotic fascia beneath. The opening through this fascia is, usually, very little due to actual removal of its substance, but is principally brought about by division of some, and separation with temporary displacement of others of its principal parallel fibres. The tendinous fibres, thus displaced, being afterwards put on the stretch by muscular action, or by movement of parts beyond the seat of injury, or by simple alteration in position of the part of the body concerned, are then caused to approach each other, and thus to narrow and contract the opening. The bullet probably pushes before it the resisting fascia upon the soft tissues below, until the connective tissue uniting the principal longitudinal fibres gives way, and allows the greater part of them in front of the bullet to yield to each side,

very few of the longitudinal fibres being actually divided; while the crossing fibres of a weaker description are either, as mostly happens, torn asunder, or are similarly separated by the destruction of their connections. The bullet opening is thus converted either into a kind of torn or fringed slit, the direction of which corresponds with the direction of the principal and strongest fibres of the fascia at the seat of injury, or into a more or less rectangular aperture bounded on each side by the crossing tendinous fibres which have been left entire, like the opening which is seen in a piece of canvas through which a round bullet has been fired. An opening closely resembling the mere slit first mentioned has been observed in the fibrous structure constituting the anterior common ligament of the vertebral column after the passage of a bullet. M. Legouest has recorded that he saw a case in which a projectile of small volume had penetrated the body of a vertebra from the front. The vertical fibres of the covering of the bone, after being traversed by the projectile, closed toward each other, so as to conceal the penetration and the fact of its presence in the body of the bone.[10] Occasionally, however, probably when the projectile is armed with so very high a rate of velocity that sufficient time is not allowed for the fibres to move aside out of the way of the projectile, the opening is no longer of the nature of a slit, but corresponds with the shape of the projectile. Such holes are less likely to occur now, when conoidal-topped bullets penetrate, than they were when the large round projectiles were commonly employed, or when angular fragments of iron form the penetrating substances.

Bullet openings in deep aponeuroses.—The deep aponeuroses and intermuscular ligamentous tissues, the sheaths of many muscles, are affected by the passage of projectiles in a similar way to the fascia investing the superficial parts of the body. The fibres of the sheath of a muscle may be so acted upon by the bullet as to be simply torn asunder and separated from each other, and thus, on being drawn together again by some cause, may cover up the hole which has been made in the muscular tissue by the bullet. But, if the sheath of the muscle be dense on both opposite aspects of a thick muscle, as happens in the rectus, and in some of the muscles of the extremities, the part of the sheath through which the bullet first penetrated is acted upon differently from that last perforated. The front of the sheath pressed towards the muscle retains its connection with it around the track of the bullet, a few of the principal fibres being torn across and their ends curled up, but not extending beyond the margin of the opening in the muscle; while on its posterior aspect, where it is pressed from the muscle, the sheath is more or less torn away, and the fibres extensively separated from each other. The front opening, therefore, appears more circular and limited, the posterior more elongated. The

same difference is met with in the openings of the aponeurotic fascia on opposite sides of a perforated limb. At the opening of entrance the connections of the fascia with the structures which it covers are but little disturbed, and the opening is more contracted than the opening of exit through the fascia on the other side. The opening of exit is rendered more free by being forced away from its connections with the muscles to which it was previously attached, and by its fibres being more extensively torn asunder. On holding a portion of fascia through which a bullet has made its exit to the light, the fascia-lata of the thigh, for example, the separation of the longitudinal fibres may be seen to extend considerably beyond the actual opening, though they are still held loosely together by crossing fibres of a weaker description and connective tissue.

Long tendons, nerves, and blood-vessels in bullet tracks.—Tendons exhibit a remarkable immunity from division by bullets. They frequently escape division though felt in the course which the bullet has taken. They must in many such cases have been pushed aside, and then have returned to their previous position, thus interfering with the continuity of the direct track so far as observation of the wound by a finger is concerned. In like manner other long and mobile structures, though not possessing equal strength and tenacity, as nerves and blood-vessels, frequently escape without being divided. When a bullet strikes direct upon and passes through a broad tendon like the ligamentum patellæ, the opening left is well defined, but, owing to the elasticity of the tendinous fibres, appears to be smaller in diameter than the diameter of the bullet by which it was caused. On the other hand, the ends of a narrow tendon which has happened to be cut across under like circumstances, usually present surfaces which are much torn and very irregular, perhaps from having been divided by the bullet against a bone, or from having been greatly stretched before giving way to the opposing force.

Bullet openings in adipose tissue and muscles.—The common cellular adipose tissue, offering little resistance after perforation, presents an opening corresponding with the size of the bullet, or, if any alteration in size occurs, the change depends probably more upon the qualities and movements of adjoining structures than upon any action of the cellular tissue itself.

The substance of the muscular structures also is endowed with but little power of resistance against the forcible passage of a bullet. The part directly opposed to the projectile is compressed, disintegrated, and carried away in front of it, or dispersed in the surrounding tissue. Sometimes a large hole irregular in shape and size, sometimes a canal-like opening, is left through its substance. The condition of the track left by the bullet is probably modified to a certain extent by the condition the muscles happened

to be in at the time of the passage of the projectile. A muscle in an active state of contraction, or passively stretched, will present a more firm and resisting substance in front of the projectile than a muscle in a condition of relaxation. There will be more complete destruction and removal of substance, therefore, in the two former states of the muscle than in the latter. In the relaxed condition of the muscle there will be more stretching and tearing, and more return therefore of its fibres upon the opening through which the projectile had passed. The track will be again modified in its characters, when the state in which the muscle happened to be at the time of perforation is afterwards changed; when the stretched muscle resumes its ordinary state of repose, and the contracted muscle returns to a state of relaxation.

Explanation of the large gaps occasionally met with in muscles.—The reasons already given will not, however, suffice to explain the very spacious gaps which are occasionally met with in muscular tissues wounded by modern bullets, when these projectiles have appeared to preserve a direct line of flight. The probable explanation in these instances is that the wounds have been inflicted by the projectiles very early in their course—when they have lost scarcely any of the destructive energy originally impressed upon them. How enormous this amount of energy is in a modern rifle-bullet, even at a considerable distance from the rifle, may be seen in the table showing the *vis viva* retained by the Martini-Henry projectile at different points of its course. Under these circumstances, just as when a bone is broken, its fragments, as will be mentioned presently, become converted into so many projectiles, so even the fluid blood, and the disintegrated particles of muscular tissue, may be propelled with such force as to act in the capacity of secondary missiles, and increase the area of laceration. When an animal near a wall is shot through the body, or through the fleshy part of a limb, by a rifle-bullet at a very high rate of speed, one effect is that the wall is more or less widely splashed with a quantity of blood. This blood has been forced by the bullet through the wound of exit. The blood has received part of the momentum of the bullet, and has itself passed onwards with a certain amount of force. If closely examined, there will be found also upon the wall and on the ground between it and the animal a quantity of particles of muscular pulp. The disintegrated muscle, like the blood, has acquired a certain velocity of movement from the projectile which has mashed it up, and itself has been turned into a projectile; as much as if tallow or any other soft material were fired direct from a musket, or as water, struck by a shot possessing great momentum, is driven with considerable initial force from the point of impact. It seems only in this way that the large gaps can be explained which are occasionally effected in the muscles by bullets of such

comparatively small diameters as the Chassepôt and other elongated projectiles when they have preserved their direct line of flight, and nothing more than soft tissues has been traversed by them.

Effects on bullet tracks of collision with bone.—If the shaft of a bone happen to be struck, the whole track of a bullet becomes greatly changed. If the bone be unbroken, the line of the track is simply turned in another direction, unless the mode of rotation of the bullet be altered, when other changes, elsewhere explained, take place. If the bone be broken, the track is altered in size, shape, and condition, according to the situation of the bone broken and to the nature and circumstances of the fracture, especially in regard to the number and shapes of the fragments, and the extent to which they have been driven into the adjoining structures. The number and shapes of the fragments, and the distances to which they are driven, will mainly depend upon the *vis viva* of the bullet that inflicts the injury; the size, power of resistance, and brittleness of the bone struck; and, to some extent, the qualities of the tissues by which it is surrounded, whether they be aponeurotic or thickly muscular. If a modern rifle bullet, armed with its full force, strike a hard and powerful long bone, like the femur for example, near the middle of its shaft, it is broken up into fragments of various shapes and dimensions, often too numerous to be counted. A large proportion of these fragments are driven violently in various directions, and are thus converted into secondary missiles. They exert much the same kind of action among the surrounding soft tissues, as a charge of irregularly shaped projectiles from a case-shot or canister. A huge hollow is formed inside the limb, which, when it is fully laid open and the effused blood sponged away, offers to view a mass of lacerated muscle intimately mixed with sharp-pointed and jagged-edged splinters of bone. The splinters have been driven forward, thrust aside, and turned round; in short, impelled with great force in all directions. They cannot for the most part be readily separated from the tissues into which they have penetrated. The muscles on the near side, that is toward the wound of entrance, are torn up as well as those on the distant side of the limb, though the latter will be most extensively disorganised. Probably the skin, on the opposite side of the limb to that at which the projectile entered, will exhibit one or more long rents through which muscle and pieces of bone have protruded. The bullet, or a portion of it, for if a leaden one it will probably be itself broken, may make its exit through one or other of these rents or by a separate opening. With all this extensive destruction within the limb, the external aspect of the wound through which the bullet first entered may exhibit nothing more to view than a small opening into which the top of the little finger enters with difficulty; thus presenting a remarkable contrast with the internal

condition of the track, and the widely-spread and irreparable mischief which the bullet has directly and indirectly done to the structures it has encountered in its passage.

As the velocity of the projectile becomes lessened, so the conditions of the fracture of bone, when fracture is effected, as well as the extent of the surrounding area of mischief, become altered. If the velocity be greatly reduced, so that the bullet becomes a spent one by the time it reaches the bone, though no fracture take place, the bone may be found to be contused, or there may be more or less abrasion of the periosteum. These lesions not unfrequently occur when the projectile by which the wound has been inflicted is a small fragment of shell, a slug, or some other irregularly shaped and angular missile of comparatively small dimensions.

Other causes which modify the shapes and directions of bullet tracks.—The principal causes of the absence of uniformity in the diameters and directions of the tracks left by bullets through parts of the body have now been explained, but there are some other minor circumstances which assist in producing them. Whatever may be the position of a limb, or the inclination of a part of the body, at the instant it is traversed by a bullet, a change of attitude of the wounded man at once changes the relative positions of the various structures composing the parts implicated in the injury. The changes which take place in the direction of the internal wound from this simple cause are often much greater than might be anticipated. The deviations of the projectile itself, produced by the different obliquities of surface of some of the structures brought into opposition to it, will often interfere with the regularity of direction of bullet tracks, or modify their forms and dimensions. Some other circumstances might be mentioned which tend to the same results, but they are all subordinate to those which have now been described.

Question of the removal of substance in bullet tracks.—It may be observed that the description which has been given of the internal condition of a bullet wound does not agree with the statement, sometimes made, that there is no removal of substance in the track of a bullet through the soft tissues of the body,—that a gunshot wound is merely a separation of adjoining parts, though, from the manner in which this separation is caused, the surfaces previously united with each other are so contused as to be deprived of vitality to a greater or less extent according to circumstances. Those who adopt this view have probably accepted it in the first place from Mr. Guthrie's remarks on these injuries. That distinguished surgeon, in explaining the nature of simple gunshot wounds of muscular parts, writes:—'The ball has forcibly torn its way through the soft parts, and by the quickness with which this has been effected, they are deprived in part of their sensibility

and life; but there is no absolute loss of substance, there is none driven out. . . . The track of the ball is then partially filled with matter deprived of life, and which must be discharged before the part can be restored to its natural state; but this dead matter retains its attachment to the surrounding substances, and must be removed by the process called sloughing.'[11] That there is, however, an absolute separation and loss of substance in the skin, connective and muscular tissues, and even in the fasciæ, when a bullet, whether spherical or conoidal, is projected through these structures with a very high rate of velocity, observations and experiments sufficiently prove.

The passage left by a musket bullet which has been projected through the reticulated tissue at the extremity of a bone affords a good typical illustration of what takes place when other organised structures, such as muscle and areolar tissue, are opposed to the action of a projectile travelling with great velocity. In the cancellated bone there is no change in appearance from elasticity, traction, or swelling, and there is no variety of structural conditions by which the results can be modified: the parts remain for some time in the same state in which they were placed by the bullet forcing its way through them, and its action upon them can therefore be studied without risk of error.

Take a direct wound of the head of the tibia made by a spherical bullet for example. If such a wound be examined after all blood has been washed away, a tunnel, of the same width as the bullet, remains. The space through which the bullet has passed is quite void. The minute interwoven fibres of bone which bounded the cells, the membrane which lined them, the blood-vessels which circulated among them, and, in short, all that entered into the composition of the structure, have disappeared.

When we examine more minutely to find what has become of the substance which has been removed, we find it disposed of in the following ways.

The *débris* of the cancelli, and the other organic structures which were attached to them, are seen to be jammed for some little distance into the cells lining the track of the projectile. The wall of the cylinder has a comparatively even and solid appearance, and has lost much of its reticulated character; partly from the lodgement among its network of the minute fine disintegrated particles which have been displaced from the part now converted into a hollow space, partly from compression and closer approximation of its own substance. If the bullet should have gone straight through, this condition will be equally marked over all the inner surface of the cylinder; if it should have passed slantingly, it is sometimes more marked on one side of the cylinder than on the other, proving that more pressure has been exerted in the former than in the latter direction.

When the bullet has not made an exit, but remains lodged in the cancellated structure, it is usually found firmly fixed in its place of lodgement. It is visibly scratched and roughened, minute particles are held in some of the scratches, and no doubt the fixation of the bullet is partly due to the points and edges of the surrounding broken laminæ getting a firmer and closer contact through this roughening of its surface. A smooth steel ball would probably be held less tightly under the same circumstances.

On examining the immediate neighbourhood of such a lodged bullet, we find a large portion of the *débris* from the shot canal collected about it. The principal portion of the disintegrated tissue is in advance of the bullet; the compressed and compact *débris*, however, surround it fully up to its equatorial limits.

It follows from this examination that the tissue broken up by the bullet in its course, and removed from its track, is partly forced into the walls of the cylinder formed by its passage, partly forced forward in front of it, and the inference is, that had the bullet passed completely through the bone, some of the *débris* which is seen lying in front of the projectile must have passed out with it and been dispersed. Indeed, we are aware that this does happen, for when the cancellated part of the bone is covered by muscular tissues, as in the shoulder, the gritty particles protruded from the shot canal can be felt in the soft tissues beyond the opening of exit in the bone, and the same thing may be observed in a gunshot wound of the head, in which similar bone particles will be found lodged about the track of the projectile in the brain.

If the bullet be one the surface of which is not liable to be scratched or indented like that of a leaden bullet, an iron one, for example, and it has not passed out, the *cul de sac* in which it is lodged will perhaps be larger than the projectile, and the ball be found lying loosely in it. The increased size of the hollow place in which it is lodged may be due to the rotatory motion of the projectile having continued after its forward motion had been arrested, as elsewhere noticed; or, if the ball has remained lodged for some time, it may be due to movements of the projectile within the cavity it has formed for itself, accompanying changes in position of the whole limb. But, whether large or small, the surface of the cavity will be found equally to be compressed, and its cells filled with broken up particles detached from other parts, so that a sort of lining is thus given to it.

When the bullet, instead of being spherical, has a conoidal front, and is projected from a rifled weapon, the amount of *débris* carried before the bullet will vary with the degree of bluntness of the apex. The blunter the apex the more closely the effects will correspond with those of the spherical bullet; the more pointed, the less of the *débris* will be pushed forward, and the more in pro-

portion will be forced into the sides of the shot canal. The walls of this canal seem to receive a greater amount of destructive pressure from the conoidal bullet in its passage, and to be more seriously crushed than when a spherical or obtuse fronted projectile of similar diameter has passed through them with the same amount of momentum; the consequence being the production of a bone wound which is most difficult to heal, as every army surgeon who has had one under his care well knows. The peculiar mode of rotation of rifle bullets must be taken into account in estimating this result of their passage. In all the instances mentioned, however, the abstraction and displacement of substance by the projectile are plainly shown.

Retention of air in bullet tracks.—Before quitting the description of the characteristic features of the internal parts of bullet wounds there is one other condition in regard to them which may be mentioned, although it is only very occasionally presented to notice. When a bullet has made a comparatively superficial wound, especially when the track is tunnelled through the areolar tissue beneath the skin, not unfrequently air will be found to be retained in it. This is shown by a slight emphysematous crackling on pressure over parts of the track, and, if the bullet have passed out, by bubbles of air being mixed with the blood which may be squeezed out at the exit opening. The presence of air in such wounds may be noticed before there has been time for any decomposition to have led to it, so that it can only be explained by its having entered the tissues at the same time as the projectile. Air probably enters on other occasions, when circumstances prevent the same evidence of its presence. The direction of the wound may favour the escape of the air by the same way it entered, or the depth of the wound may place it out of reach of observation, and thus the occurrence may elude notice.

Tracks left by explosive bullets.—We have very few surgical observations of the characters of wounds inflicted by explosive bullets from their actual use in war.

Dr. Scrive, in his history of the Eastern Campaign of 1854–56, mentions that explosive bullets were employed by the Russians. According to Dr. Scrive's description, some specimens which were found at Sebastopol after the capture of the place, consisted of a small cylinder of copper containing a detonating composition. They were made up in the form of cartridges, and were arranged for being discharged from ordinary muskets. The discovery of these projectiles, Dr. Scrive remarks, afforded a key for explaining some wounds of a frightful character, which could not be accounted for by the action of ordinary bullets or fragments of shells.[12]

I did not myself see any wound during the campaign which could be ascribed to the effects of an explosive bullet. Dr. Brush,

surgeon of the Scots Greys, has given me the particulars of a wound in one of the troopers under his surgical care at the battle of Balaclava, which seemed as if it had been caused by an explosive bullet. The wound was in the popliteal space of the right leg, its edges were jagged and blackened as if burned by powder, the opening was large enough to admit two fingers, and Dr. Brush on passing them downwards as far as they could reach, found the muscles of the calf reduced to a pulpy mass. The man was removed to the General Hospital at Balaclava, and the limb then amputated by another surgeon, but unfortunately does not appear to have been afterwards inspected. Dr. Crosse, of the 11th Hussars, has also given me the notes of a case which occurred at the same battle, and which he was led to attribute to the action of an explosive bullet. The wound was received in front of the tibia, just below the knee, and the bone was shattered. The shock was so great that considerable time had to elapse before amputation could be performed. The pressure of duty at the time prevented a particular examination of the limb after amputation. Explosive bullets are said to have been occasionally employed in the late war of the rebellion in the United States, but I am not aware that evidence is available to show the extent to which they were used. The collection of projectiles in the United States' Army Medical Museum at Washington contains specimens of cartridges with Gardiner's elongated shell-bullets for rifled muskets, and of other explosive balls from the United States' Ordnance Department.[13] Major Von Borcke, in his 'Memoirs of the Confederate War for Independence,' when describing an engagement near Fredericksburg, in the summer of 1862, writes, 'In this combat I also saw for the first time exploding rifle balls used in action. They fell on all sides, bursting with a crackling noise in the trees and on the ground, without doing much execution.'[14] If we may judge from the few examples of them among the very large collection of projectiles extracted after flesh wounds, or after contact with bone, in the Washington Army Medical Museum (only one such bullet and two metallic fragments, supposed to be parts of explosive balls, being noted as far as I have observed in the catalogue[15]), these projectiles would not appear to have been much used by the armies of either the Federal or the Confederate States.

The effects of some conical shell-bullets, invented by Major Fosbery, were tried during the Umbeyla Campaign on the North-west frontier of India in the year 1863. They were fired from Enfield rifles. Major Fosbery had with him thirty-two marksmen selected from the 71st and 101st Regiments, who were employed for several weeks on outlying pickets, or with skirmishing parties, and used these explosive bullets. The military results of the experience gained on this occasion have been published,[16] but I have been unable to obtain any observations from surgeons who were present

on the character of the wounds produced by these projectiles. The opportunities of examining them were probably very limited in number, as the mountain tribes against whom the bullets were used succeeded in carrying away a great proportion of their dead and wounded. A non-professional writer in the *Times*, however, when writing on the military results of the explosive bullets on this occasion, mentioned that a few wounds came under his observation; and remarked that 'in one instance the bullet had entered the back of the neck, and then exploding, had entirely blown away the face, while in another, where the bullet had struck just over the heart, the effect was even more terrible to witness.'[17]

In consequence of the absence of reliable information respecting the characters of wounds inflicted on men by explosive bullets, and the repeated allegations that have been made in recent wars by the opponents on both sides of their employment, I thought it might be advantageous, as a guide to what might be expected to follow their use among combatants, to collect information on the principal features of the wounds inflicted by them on the lower animals. Some of the best known sportsmen in India kindly assisted me in my inquiries. The result of the investigations may be summed up as follows:—

When an explosive bullet bursts within a cavity of the body without striking bone, the bullet is sometimes simply rent open, sometimes burst into many scattered pieces. The viscera of the cavity are generally torn to pieces or pulpified. If examined early, the cavity is found to be filled with gray smoke, wreaths of which often make their way and curl from the wound of entrance. The escape of puffs of smoke from the wound, when the projectile has burst fairly within a part of the body, lasts for a considerable time after its infliction on the wounded part being subjected to movement, and is very characteristic of the special means by which the wound has been produced. The ribs, the spine, and even the bones of the pelvis and extremities of the most powerful savage animals are liable to be broken by explosive bullets. When the shell bursts among muscles, a huge gap from 4 inches to 6 inches in diameter may result, the soft tissues being reduced to a jelly-like mass. The surrounding structures exhibit signs of being burned, the degree of burning being very varied. Explosive bullets, however, frequently pass through the muscular tissues, and only explode on striking bone. The bones sometimes escape fracture when they have apparently been struck, but they are often found smashed to pieces. When the bullet explodes in a limb, blood is widely extravasated and is forced between the muscles to a great distance beyond the principal area of destruction, frequently dissecting them, as it were, from one another. There is also considerable emphysema from gas being forced into the areolar tissue. The muscles, for a long distance, are darkened in their substance, and

appear as if they had been contused. Decomposition takes place speedily in the parts around the site of explosion. A sulphurous odour pervades the tissues: this arises from the fact that the explosive mixture used in India has ordinarily consisted of sulphuret of antimony and chlorate of potash. Injuries from explosive shells, even where they do not inflict wounds of a fatal character, are almost invariably attended with great shock to the nervous system. Explosive bullets are very uncertain in their effects, sometimes exploding on first striking the surface, sometimes passing through without exploding at all, sometimes almost entirely destroying the animal hit by them, so that their employment is now discarded by many sportsmen.

CHAPTER IV.

CHARACTERISTIC FEATURES OF INJURIES PRODUCED BY SMALL SHOT.

Circumstances which modify the characters of injuries by small shot.—Small shot produce injuries which differ very materially in their appearances and their nature, according to the distance from which the shot have been discharged, their size and number, the charge of powder, the kind of cartridge employed, and the quality of the fire-arm. This is the result of the fact that on leaving the muzzle of the fire-arm the shot assume the outline of a diverging cone, of which the 'spread' or degree of divergency varies according to the different circumstances above enumerated.

When the fire-arm is loaded, as it used always to be in former days, by pouring the shot on the wad which keeps down the charge of powder, the shot are more scattered than when they are fired from machine-made cartridges, such as are in common use with breechloaders.[18] One effect of these cartridges is to keep the shot more together and to cause them to maintain this mutual proximity to longer distances.

Small shot fired close to the body.—If the weapon be held close to the surface of the body, so that the wad and shot enter together in a mass, and no bone intervene, a large proportion of the charge will probably pass through the wounded part completely. The vacant opening left by the entrance of the shot will present much the same general characters as if it had been made by a single missile. The wound of exit will be much larger and more ragged. This will depend, however, upon the distance at which the exit is effected and the nature of the tissues through which the shot have passed. If near at hand, through a fleshy part, the exit wound

will be large and greatly torn, owing to the spread of the shot and some of the wounded tissues being carried along with it through the opening; if distant, many of the shot will be caught on the way, and broken up tissue will not find the same means of escape. The entrance wound will also be attended with an amount of charring and blackening from the effects of the flame and smoke, similar to what would accompany a bullet wound under like conditions. But internally there will be greater laceration and destruction owing to the divergent scattering of the shot and the distances to which some of them are driven, than there would be had the projectile consisted of a single bullet. The rending and contusing effects due to the blow and expansion of the volume of gas from the exploded powder would be alike in both cases.

If the shot meet a bone, such as one of the long bones of the extremities, or a rib, when the shot has been discharged from a fire-arm touching, or close to, the body, the bone will probably be shattered, and the destruction of the surrounding soft parts will be still greater, because of the deflection of the shot. Most of the shot which do not lodge in the broken bone are scattered around on all sides, tearing up the tissues into which they have been driven. Some shot and some of the fragments of bone, if the wound be in one of the extremities, will probably be driven out through the opposite side of the limb, causing torn and irregularly shaped wounds in that direction. If the bone be over a cavity, as in the instance of a rib, the principal part of the charge of shot and perhaps some of the fragments of bone will penetrate, and spread through the substance of the organs within. A few stray shot will not improbably pass to a distance beyond the wounded viscera, while some will remain in the substance of the bone itself, and some others be deflected and lodge in the adjoining muscular parietes. In such a case there is rarely any wound of exit.

If the charge impinge upon bones in which the cancellated structure prevails, as among the bones of the tarsus for example, although the bones may not be broken, a large proportion of the shot will become deeply imbedded and remain lodged in their substance. The extent to which the shot may be disseminated under such circumstances may defeat all attempts to repair the injury. A charge of No. 4 shot fired a few inches off entered the right foot of a soldier, two inches in front of the outer malleolus, and made an exit close to the inner malleolus. Attempts were made for a long time to save the foot, but in vain. Nearly two years afterwards it was amputated at Netley, when not only the astragalus, but the os calcis, scaphoid, and cuboid bones, were found studded with shot throughout their entire texture.

Charge of shot fired within a foot from the body.—If the fire-arm be discharged from a distance not greater than twelve or perhaps fourteen inches, or at any less distance from the surface,

the shot will still enter in a mass, but the opening will be larger and the edges more lacerated than when the fire-arm is quite close to the body. In a case in which a charge of shot entered the thigh rather obliquely from about the distance named, the entrance opening was an inch and a half by one inch in size. No detached shot will be scattered around the principal opening, or but very few will strike separately.

Charge of shot fired at about five yards' distance.—Beyond a foot and up to about five yards a portion of the shot, presuming the surface struck to be uncovered, will still pass in a mass inflicting a central wound, around which there will be other wounds from scattered shot. Clothing or covering of any kind will of course modify the effects according to its nature and thickness. The wound will be very irregular in outline, with its borders scalloped by the shot and generally inverted. The number of shot which wound in a mass, the number which are scattered around the wound, and the extent to which they are scattered, will all vary as the distance is varied.

So long as there is a large open wound bearing any resemblance to a bullet wound, the explanation is to be found in the fact that it is not inflicted by a single layer of shot, as it were, but by successive layers. Shot behind closely follow those in front, so that not only are openings made by the shot which first strike, but any tissues that may remain to connect these openings are broken up and other openings produced by the shot which follow. The whole of the tissues are thus completely destroyed, and an open blank remains. When the shot have diverged to a certain extent all the shot travel in different paths, and they then strike singly, and as a rule, unless a shot happens to strike an important part as the eye, without any serious results.

Charge of shot fired beyond five yards' distance.—Beyond a range of five yards there will probably not be any central wound, but still, if the fire-arm be not far removed from this distance, a proportion of the shot will be more closely congregated at a spot corresponding with the line of fire than elsewhere. The rest of the shot will be scattered at increasing distances from each other as the distance from the centre of collision is increased.

Charge of shot fired from about 50 yards.—At a distance of 50 yards some shot will still retain sufficient energy to enable them to penetrate the surface, but they will usually not sink beneath the fascia. They are commonly found imbedded in the subcutaneous areolar tissue, whence they can generally be extracted without difficulty immediately after the infliction of the wound.

Effects of small shot on blood-vessels, nerves, and some other organs.—The divergent laceration caused by small shot within short ranges has an important bearing when the shot passes

through structures in which vessels and nerves of large size are contained. A vessel which might possibly escape by yielding to the pressure of a bullet in its passage has scarcely any chance of avoiding division or destructive contusion when it is rained upon, as it were, by a small shower of shot from a fowling-piece. Tendons and ligaments are equally subject to irreparable destruction under the same circumstances. A charge of shot through the wrist or forearm will rarely leave scope for any other proceeding but amputation. Similarly destructive results usually ensue when charges of shot have force enough to pass into cavities of the body and to traverse any of their contained viscera. There are various chances of escape, even though a bullet may perforate the abdomen, or penetrate the chest and pass through a lung, but scarcely any with a charge of shot under like circumstances. The cone of divergence is usually increased in diameter by the effects of the passage of the shot through the wall of the cavity, and the involved viscera are consequently penetrated in numerous directions; the tissues intervening between the openings are extensively rent and bruised; and single shot diverted by accidents of impact in passing through the wall of the cavity penetrate other organs at various distances from the principal focus of damage. The walls of wounded cavities are also themselves often extensively injured beyond the site of the chief wound, for some of the shot in passing through the several layers of which these walls are composed, especially when some of them are tendinous, are apt to be deflected, to travel separately at various angles to considerable distances, and thus to widen the area of injury.

Wounds by single shot.—The small size of a single shot, and the readiness with which it may be deflected and lie concealed in parts remote from the orifice of entrance, necessarily lead to much difficulty in discovering it, even when careful examination is made after death. The external marks of a wound by a single shot may be so slight as to be unnoticed unless a close search be made. Yet cases have been recorded in which fatal consequences have resulted from the entry of even such a small projectile as this. The brain has been penetrated by a shot through the orbital plate of the frontal bone, the aorta through the chest, and death in each case has been the consequence.

Rased wounds from small shot.—When a charge of shot fired close at hand traverses superficially some part of the surface of the body, the integuments and some of the muscular structures beneath will be excavated and carried away, and a lacerated and contused wound with much ecchymosis will be presented to view. Some of the shot are generally caught and embedded in its surface. The integument bounding the wound is torn irregularly, separated to some extent from the subjacent tissues, blackened, and

hangs about, showing that it is deprived of its usual elasticity. If nerves and arteries have happened to be in the way of the shot, they also are torn and generally in part shot away. The effects of a rasing charge of shot, such as that just described, become modified as the distance of the point of discharge is increased, in the same way as has been described with regard to point-blank wounds.

When part of a charge of shot fired from a considerable distance has penetrated the surface slantingly, it may still be expected that some of them will travel to long distances from the wounds of entrance. The shot cleave their way very readily through the connective tissue which binds the muscles or other organs together. The readiness with which this happens is one reason why these slanting wounds so often give rise to troublesome complications and require prolonged treatment.

Effects of small shot on parts covered with clothing.—When a charge of small shot enters a part of the body which is covered by clothing, the shot generally carry some fragments of cloth in with them. They do this, indeed, more commonly and more extensively in proportion to their size, than larger projectiles, such as musket and rifle bullets.

A spherical bullet, when it penetrates a part of the body covered with clothing, especially when the clothing has been put upon the stretch, as happens with a sleeve of his tunic when a soldier's arm is bent in front of him, or with the upper part of his trouser when he is kneeling, usually punches out a portion nearly corresponding in shape and size with its own circumference. But if the velocity of the spherical projectile be lessened, or if the clothing which covers the part it happens to impinge upon be free and loose, or if the bullet be one with a narrow diameter and tapering front, the accident of a portion of the clothing being detached and carried onward by the projectile is frequently avoided. The cloth or linen is pushed forward by the projectile for a certain distance, when its fibres yield, an opening is made, and through it the bullet pursues its course.

With small spherical shot the case is different. The shot, being fired in close contact, often lose their round form and become more or less flattened, in consequence of the character of the force impressed upon them at the time of their discharge from the fowling-piece. Striking in a shower, as it were, they mutually counteract the tendency there might be, at any given point, for the covering to elongate itself and split up. Each shot tears away a small portion of the woven material opposed to its passage, or, when two or more shot strike near each other, they carry away not only the portions directly opposite to them, but also some of the intervening cloth by which those portions were connected.

The amount carried away, however. will depend upon the kind of clothing, whether it be of a texture that parts asunder readily, or whether it be tough and elastic. A charge of shot passing through a boot and stocking into the foot may not carry any of the leather into the wound, but will almost certainly carry fragments of the stocking into it. This happened in the case of shot wound in the foot before referred to. The man had a Wellington boot on when he was hit, and the charge entered through it. Some of his cotton stocking was carried into the wound, but not the leather. The back of the boot was not cut: the portion of the charge which passed out of the foot was found mixed with coagulated blood in the boot itself.

SECTION IV.

ON THE PRIMARY SYMPTOMS AND COMPLICATIONS OF GUNSHOT INJURIES.

Introductory remarks.—In the preceding section the conditions which result from the local physical effects of the strokes of projectiles have been described; in the present section the symptoms which generally attend the production of these effects, and certain complications with which they are liable to be accompanied, will be particularly noticed.

The *symptoms* which are common to most gunshot injuries are (A) pain, (B) shock, and (C) primary hæmorrhage. In connection with the subject of primary hæmorrhage some remarks will be made on the thirst which so frequently exists in an intense degree among men suffering from gunshot wounds on fields of battle. The primary *complications* of gunshot wounds which will be described are (D) lodgement of foreign bodies, (E) burns, and (F) multiplicity of wounds.

CHAPTER I.

ON PAIN AS A PRIMARY SYMPTOM OF GUNSHOT INJURIES.

Causes which modify this symptom.—The amount of primary pain which accompanies the infliction of a gunshot wound, more particularly one by a bullet, varies very greatly in degree according to the kind and situation of the injury, together with the condition of mind and the state of constitution of a soldier at the time of being hit. It is not a symptom which affords any reliable indication of the nature or degree of gravity of the wound which has been inflicted. In very severe wounds pain is usually deadened either by annihilation of function and sensation of the parts wounded, or by the state of stupor into which the shock of the injury has at once thrown the patient. In occasional cases of nerve injuries pain is extremely intense from the first, and continues so unless relief be afforded, so that this symptom itself becomes a source of danger to the patient. This occurs, however, only in very

exceptional instances. In most cases the early pain, even if severe, is very evanescent, is followed by a certain amount of numbness, and only recurs after reaction sets in.

Various degrees and kinds of pain felt by wounded men.—Wounds that are directly mortal are sometimes accompanied by a loud shrill cry at the instant of their infliction. The utterance of this piercing exclamation, distressing to comrades as it is to hear it, and all the more so from the mutilation and other startling circumstances with which it is often associated, can hardly be regarded as an indication of conscious suffering. It is probably analogous in its nature to the cry of the hysterical, the spasmodic scream which attends destruction of life by prussic acid, and to the yell of the epileptic.

In other instances in which this directly fatal character does not exist, temporary loss of consciousness immediately follows the infliction of the wound. The patient falls bereft of sense, and in that condition remains for a longer or shorter time according to circumstances. When this occurs, although the infliction of the wound may have been attended by instant pain of a severe character, no recollection of it is afterwards retained.

In cases where loss of consciousness does not follow gunshot wounds the accompanying sensations may, or may not, be noted by patients; and when noted, the impressions entertained of its nature and character will be found to differ most widely. It may be readily understood why such discrepancies should occur.

The extreme suddenness of a gunshot wound, its startling nature when its infliction is perceived, and the previous occupation of the soldier's thoughts, probably intently engaged on some of the exciting scenes around him, may well prevent him from observing and noting his sensations at the moment of being wounded with any approach to accuracy. The occupation of the mind may be so intent in other directions that the passage of the bullet may not be noticed at all. Soldiers who are the subjects of simple flesh wounds will frequently tell surgeons that they were not aware when they were struck. The truth of these statements is confirmed by the fact that instances are not rare of soldiers continuing in action after they have been hit. Men in a state of excitement, especially when overstimulated by the close proximity of their enemy, have been often known to fire several rounds after having been wounded, only leaving off when faintness and a feeling of nausea from loss of blood have occurred, and compelled them to desist from exertion; or when accidental observation of the blood proceeding from their wounds has made them acquainted with their condition. Had they been previously aware of what had happened, they would have ceased to fire, and sought for help. The fact that the very part which has been wounded was at the same time engaged in some active exertion may help to divert the mind from

taking notice of the pain accompanying the wound. Thus a man receiving a flesh wound of the arm while in the act of firing his musket may mentally attribute the sensation, really due to the entry of a bullet, to the effort of firing his musket, or to the recoil of the weapon at the time of its discharge. Or he may connect it with something that is happening in his immediate neighbourhood which might produce a feeling of pain similar in character to that which has been caused by the projectile. A soldier of the 23rd Regiment was wounded at Amoaful during the last Ashanti war near the bend of the elbow. He was in the act of loading his rifle under the shelter of a tree when he was hit. He felt a blow as if he had been struck by a stick; pieces of branches were being knocked off around him and he considered at the moment that a fragment of the tree above had fallen and hurt him, and then thought no more about it. After firing his rifle three times, the captain of his company who was standing by told him he had better go to the rear as he was wounded. The man himself was not aware of the fact until the officer informed him of it, although, as it turned out, a slug had passed deeply into the arm. Sometimes a soldier will have received two or more wounds, and be only aware of the occurrence of one or other of them according to circumstances. Instances are not wanting in which an important bone even has been broken,[1] and, although the occurrence has been accompanied with a violent shock, the local pain has not been such as to make the soldier conscious of the severe wound which has happened to him. Under the excitement he has attributed the shock to some other cause, and has only become aware of what has really happened when the limb to which the broken bone may have belonged has dropped from its support, or on making some exertion which has led to his fall, and so betrayed to him the nature of the injury to which he has been subjected.

Effect of velocity on pain.—Perhaps the occasional unconsciousness of the passage of a bullet through organised structures may be not merely due to the fact of important nerves having escaped collision and injury, but may also be accounted for by the projectile having been armed with nearly its highest rate of velocity at the time of making its transit. The bullet has travelled through the parts almost as instantaneously as a flash of lightning. Practically it has not encountered any opposition in its path, and its progress has been unaccompanied by transmission of violence to the surrounding structures. It has been elsewhere shown that the Martini-Henry bullet travels the first 400 yards of its course in one second; supposing it to pass through six inches of the fleshy part of a man's arm at the same rate, it would traverse the part in $\frac{1}{2400}$th of a second of time. Under such circumstances, it may well happen that no knowledge is obtained by a wounded man of the sensations accompanying the passage of a projectile, because there is not time

for the local impressions which are made at the instant of its transit to be conveyed to the brain.

Descriptions by patients of the pain of gunshot wounds.—As a general rule, however, the patient is alive to a certain amount of pain accompanying the forcible entry or exit of a bullet, even in uncomplicated flesh wounds. Occasionally this pain is described as having been like a flash of fire; or like the sharp stinging pain from a sudden smart stroke of a cane; or, in other instances, as the shock of a heavy intense blow.

Of pain at the wound of entrance of a bullet.—Sometimes without any distinct local manifestation of pain at the moment of being struck, there is still a consciousness that an injury has been received somewhere in the neighbourhood of the wound of entrance. A blow or shock is felt at the part, and the man concludes that he has been wounded, but does not know precisely where the wound is till he looks for it, or the appearance of blood indicates its situation. Occasionally, when the local pain is distinct and sharp enough, its peculiar character leads the man to attribute it to some cause which usually gives rise to it, and not to the effect of shot, notwithstanding he is under fire, and that therefore the probability of his receiving a wound might be expected to lead him to attribute every sudden painful sensation to injury from a shot. A hospital sergeant, who served with me, had been wounded in the leg by a musket ball at Calpee. The bullet passed through his trousers, and caused a small rasing wound a little above the ankle, and about two inches in length. The sensation given was precisely as if some insect had stung him. He brushed it away as he thought, and went on with what he was doing, but presently the warmth from the blood flowing within his sock attracted his attention, and the wound was discovered.

Pain at the wound of exit of a bullet.—In some instances no pain is noted at the entrance wound, but is distinctly felt at the wound of exit. A private of the 7th Fusiliers was in face of the enemy at Inkerman. A bullet pierced the lower and outer part of his neck, and tore its way out behind, between the upper angle of the scapula and the spine. An officer of the 2nd Batt. Rifle Brigade was behind him. No idea of having been shot entered the private's mind. He was not even aware of the wound he had received in front, but his sensations led him to suppose that the officer behind had pricked him with the point of his sword in the back. He turned round instantly to learn what this was done for, and was in time to see the officer in the act of falling. The bullet which had just passed through his own neck had struck the officer in the head and killed him. I have heard my father refer with amusement to the sudden anger of another officer in front of him who, on some occasion of effecting a landing before an enemy, was hit by a bullet through the fleshy part of the thigh, while the party were advancing on the

sea-beach. He had no idea at the time that he had been shot, but turned round in a rage on the supposition that some one had struck him a sharp blow from behind. Similar instances of the stroke of a shot being mistaken for a blow from a neighbour, have been related to me by men who have been wounded. Curiously enough in such cases the momentary impression seems usually to be that the blow has come from somebody in rear; so that the chief part of the sensation has probably been derived from the wound of exit. This may be due to the lessened velocity of the bullet, and greater stretching and tearing of the sentient surface at the place of its escape.

Pain along the tracks of bullets.—In simple flesh wounds, and in all wounds in which important nerves and bones are not struck, when pain has been felt and has been noted, it seems generally to have been referred to one or other of the surfaces, either at the wound of entrance or that of exit. Even in cases where the velocity of the projectile is comparatively not very great, when it does not effect a wound of exit, but lodges under the skin at some point opposite to that at which it entered, pain along the track of the wound is not remembered. A man, who has been shot through the abdomen or chest without vital parts being implicated in the wound, usually describes the sensation communicated by the penetration of the shot as that of a violent blow *on* the belly or chest, and a man similarly injured in one of the extremities describes some kind of pain *on* the limb at or near the part wounded. The following is the only instance I have met with in which there appears to have been consciousness of pain throughout the course of the bullet —at the entrance, along the track, and at the exit. The patient was a medical officer, Dr. Chalmers Miles, who was shot during the Sepoy mutiny, in an attack on a fortified place not far from Neemuch. The description of the wound is in Dr. Miles's own language. 'Just about this time I was shot through the thigh by a bitten musket bullet—one of those implements of war which cause immensely unpleasant and jagged wounds. The feeling when you are hit is peculiar; it is just as if a red-hot iron was suddenly plunged into your thigh, and the channel it formed filled with molten lead; then a scalding unpleasant pain passes through you; and then there is a sensation of faintness, yet relief, and the ball is out.'[2]

Pain of bullet contusions.—When a bullet does not penetrate the flesh, but simply inflicts a contusion, the pain caused by the injury is often described by patients as having been more severe than the pain which is spoken of by those patients in whose bodies the bullet has effected an entrance. In such cases, in addition to the direct injury to the sentient nerves of the skin, and to the sub-tegumentary tissues, at the particular spot struck, the extent to which the impetus is communicated to the parts surrounding the point of

impact of the bullet, and the great stretching to which these parts must be subjected, must also be taken into account in explaining the severity of the pain complained of. In a wound made by a bullet moving at full speed this strain upon the surrounding tissues can hardly take place, for the resistance of the parts opposed to the projectile is instantaneously overcome and a passage freely opened to it. The sensitiveness of the skin at the wound itself is at the same moment numbed, or even annihilated by destruction of its vitality.

Special sensory effects from injuries to nerves.—Occasionally, when the trunks of nerves are directly injured,—not divided, but violently pushed aside,—the wound will be accompanied with intense pain, but none will be experienced locally; the pain which is felt will be referred far away from the track of the projectile to some distant part to which the nerves are distributed, or for an instant a portion of the limb will be thought to have been completely carried away by the shot. I have known a wounded officer in the Crimea so deceived from the cause mentioned as to support an unwounded arm all the way from the Redan to the trenches, on the supposition that his hand and forearm had been shattered by a shot. He had been wounded through the neck, but was not aware of having been hurt in that situation. It has happened that a patient who has sustained a wound, in which nerves have been implicated, in one limb, has thought that the wound was in the opposite limb. Dr. Mitchell, of the United States, has mentioned two cases in which wounds of one leg seemed to the patients to be really in the unwounded limbs,[3] and has referred to other cases of a similar nature. Less rare cases are those in which pain is not only felt in the wounded limb, but reflex pain is also felt in the opposite uninjured limb, in parts corresponding in function with those at the seat of injury.

CHAPTER II.

ON 'SHOCK' AS A PRIMARY SYMPTOM OF GUNSHOT INJURIES.

Description of shock.—When a large bone is suddenly shattered, a cavity penetrated, an important viscus wounded, or a limb carried off by a shot, one of the most marked features of the injury is a general disturbance of the nervous system, which shows itself by strongly marked bodily and mental agitation. In most cases, this perturbation supervenes instantaneously on the injury. This symptom is generally described as the 'shock' of a gunshot wound. The patient trembles, totters, is pale, depressed, complains of being faint, perhaps vomits. The surface of his body

has lost its natural warmth. His features express the vacancy of stupor, and more or less anxiety and distress. His circulation is weak and agitated; the respiration feeble and labouring. A trembling emotion may be observed in a horse which has received a deadly wound in action, just the same as in his rider. It may be regarded as an expression of sympathy of the whole frame with a part suddenly subjected to serious injury. The prostration of shock must not be confounded with the prostration, or collapse, which results from copious loss of blood. The tottering and trembling condition of the body, and the stunning of the senses which are so characteristic of shock, are hardly noticeable among the symptoms of faintness from hæmorrhage. At the same time, as both drain of blood and nervous shock produce similar results, though by different paths, on the centre of circulation, there are necessarily many symptoms in common between them. Neither should the effects of shock be confused with those produced by direct injuries of the brain or spinal cord.

Variations in degree of shock.—The shock of a gunshot wound is more or less marked in degree according to various circumstances. Examples show that it may occasionally be altogether overpowered for a time, even in very severe injuries, by moral and nervous action of another kind, or by a state of mental tension, but this rarely happens when the injury is a vital one. One difficulty in estimating the amount of shock in particular cases is that panic, when induced suddenly, leads to symptoms which closely simulate those of severe 'shock.' A soldier having his thoughts carried away from himself, his whole frame stimulated to the utmost height of excitement by the continued scenes and circumstances of the fight, when he becomes conscious that he is wounded is instantaneously recalled to a sense of personal danger; and, if he be seized with doubt whether his wound is mortal, depression as low as his previous excitement was high may immediately follow. This alarm, and the depression induced by it, will vary in degree according to individual character and intelligence, state of general health, the structural condition of the heart, whether vigorous or weak, and other personal peculiarities. If the emotion be as intense as it is sudden, it alone will induce a rapidly fatal result in some individuals. In others of a different temperament the alarm and depression will be controlled, and even extraordinary energy be manifested in its stead for a time. Numerous examples occur in every action of men walking long distances to field hospitals for assistance, unsupported and with comparatively little signs of distress, after a gunshot fracture or even the loss of an arm, a perforating flesh wound of the thigh, or some other such severe injury; and only, after arrival at a dressing station or field-hospital, exhibiting the usual symptoms of shock. Among the collection of drawings by Sir Charles Bell, at Netley, is one of

a sergeant of cavalry who had his left arm completely carried off near the shoulder by a round shot at Waterloo; yet, in this condition, he started off and rode upright all the way from the field of battle to Brussels, a distance of fifteen miles. On reaching a ward in the Elizabeth Hospital, he became utterly prostrate from the effects of shock, and remained insensible for half an hour. On the other hand, it not unfrequently happens that men with comparatively slight wounds are quite overcome and require to be carried from the field. It is not easy in many of these latter cases to determine how much of the symptoms presented is due to alarm and how much to true 'shock.'

Duration of shock.—The duration of shock, when it exists as a temporary condition,—that is, when it is not associated with any fatal injury—is as varied as is the degree in which it is met with at the onset of a gunshot injury. It may pass off in ten or fifteen minutes; it may remain four or five hours, or even longer, and then pass away. Nor can the period during which it will last be calculated from the amount in which it is exhibited immediately after an injury. Excessive shock will sometimes pass off with comparative quickness, while the persistence of moderate shock is often very prolonged. These differences, again, seem to depend upon constitutional peculiarities; perhaps on the extent to which the centre of circulation is susceptible to the influence of the nervous system, perhaps to the fineness of the sympathy which exists in the ganglionic system. They cannot always be explained by the relative degrees of gravity of the wounds concerned.

Recovery from shock.—As the shock is disappearing, the pulse gradually resumes its regularity, the paleness changes to the natural hue as the capillary circulation of the surface of the body is restored, the mind gradually regains its power, awaking, as it were, from a state of abstraction and of general undefined apprehension to take a discriminative interest in the local injury which has been sustained, and to consider its nature and consequences with judgment. Even moderate uneasiness and pain at the seat of injury become noticed by the patient. In short, a gradual improvement, bodily and mental, takes place until the normal state of tranquillity is restored, and nothing remains beyond the particular local disturbance which has been directly produced by the violence of the shot.

Effects of shock on hæmorrhage.—One effect of shock is to lessen the impulse of the heart's action, and thus, for a time, like fainting, to lessen the risk of fatal hæmorrhage in case of an important artery having been opened. But, equally with what happens in fainting, as the heart recovers its vigour, and the circulation recovers its usual force, so the danger of a return of hæmorrhage is increased. The reaction of shock is very similar to the reaction of faintness, though arising in different ways. The

necessity for watching the return of bleeding under such circumstances, and for being prepared on the instant to check it, is a matter that should not be forgotten, especially if a patient has to be entrusted to untrained bearers during removal from one place to another, or is left in the hands of uneducated hospital attendants.

Relation of shock to amount of injury.—As a general rule, the graver the injury the greater and more persistent is the amount of shock. A rifle bullet, which splits up a long bone into many longitudinal fragments, inflicts a very much more serious injury than the fracture which was ordinarily produced by the ball of the smooth-bore musket; and the amount of constitutional shock usually bears a like proportion. When a portion of one, or of both lower extremities is carried away by a gunshot, the higher towards the trunk the injury is inflicted, the greater may be expected to be the shock, independently of the loss of blood, panic, or other depressing circumstances.

The following case is, however, well suited to illustrate the fact that shock may occasionally induce a speedily fatal result after an injury which in itself can hardly be regarded as one of extreme gravity. Dr. De Chaumont, now Professor of Hygiène at the Army Medical School, was with a party of men during the Crimean war in one of the ravines leading to Sebastopol, when two of them were struck by a gunshot from the great Redan. The first man struck was killed immediately. The second, who was by the side of the first, received the force of the shot along the upper arm, between the shoulder and elbow joints. The arm was near to the rocky side of the ravine at the time he was wounded, but so far as external evidence was concerned, there was nothing to show that it had been crushed by the shot against the rock. The integuments were sound, and as normal in appearance as if no projectile had passed near them. On examination, however, the shaft of the humerus was found to be shattered to pieces. The injury was followed immediately by symptoms of shock so extreme in degree that all attempts to rally the soldier from them failed, and the man died almost without power to speak a word from its direct effects. No internal viscus had been injured. This was ascertained by examination of the cavities of the body after death, nor was there any reason to believe that any part had been injured in addition to the one already described.

Nature of shock.—The nature and influence of shock are subjects of much practical interest to military surgeons in other directions. On the views regarding them decisions often depend regarding the propriety of performing important surgical operations while the shock exists, or of delaying them until after the shock has subsided.

In the present state of knowledge it is hardly possible to explain the nature of shock with precision, though the condition

itself may be sufficiently described by its effects. When knowledge of the physiology of the nerves is considerably further advanced; when manifestations, to which are given the names of nervous excitement, nervous exhaustion, and the like, are better understood, then, but not till then, shall we be able to say with accuracy on what conditions true shock depends. Some surgeons, in accounting for 'shock,' lay great stress on the concussion, and direct mechanical effects on the whole body, including the nerve-centres, from the momentum of the shot, but this explanation will hardly prove satisfactory if it be generally applied. In many instances in which shock is strongly manifested, there is abundant proof that no such general physical commotion can have taken place. That true shock, as distinguished from shock resulting from violent physical concussion, from mental depression after unusual excitement, or from the effects of panic on the part of the patient, is a phenomenon, the essential relations of which are connected with vital force, and with that endowment of the organisation only, may be judged from observation of cases of bullet wounds in which the injury inflicted is inevitably a fatal one. In such wounds the shock remains from the time of the first production of the fatal impression till life ceases. The practical experience of every army surgeon teaches him that when a bullet has entered the body, and the shock continues without any relief or evidence of reaction, internal organs essential to life have been involved in the injury.

Wounds causing death by shock.— It is very rare that shock of a fatal character occurs after gunshot wounds involving only one of the extremities, especially one of the upper extremities, as happened in a case previously related. In injuries involving a considerable extent of surface; in penetrating wounds of the abdomen; in cases of extensive destruction of the femur by projectiles, particularly by gunshot, fatal results are not unfrequently due to the effects of shock. In the surgical history of the Crimean war there is an extract from the records of the general hospital in the British front, showing the causes of death in 100 fatal cases taken consecutively as they happened to stand in the admission book. Out of these fatal cases 22 are recorded to have died directly from shock, some within three or four hours, generally within 24 hours, after the wound was received. In only one of these cases was the injury confined to a primary wound of either the lower or upper extremity. This was a compound fracture of the femur from gunshot. In two other cases the thigh was also the region injured, the limb in one having been carried away by a gunshot, in the other its lower half with the knee joint having been destroyed by grape shot; but, in both of these, amputation above the wounded part was performed, so that the superadded injury of the amputation has to be taken into account as

regards the death from shock. Out of the 22 fatal cases, in 13 the abdomen had been penetrated; in 2 the pelvis; in 1 the chest; in 1 there was an extensive wound of the lower part of the face; in 3 the femur, with amputation in two instances; and 2 were extensive burns from explosion of gunpowder, one of these being complicated with fracture of the leg, fore-arm, and inferior maxilla. It is interesting to observe the preponderance of injuries to the abdomen in this list of deaths from shock—13 out of 22 cases.

Wounds from large projectiles lead to death from shock more frequently than those from small projectiles. They seem to produce the same effects in this respect as the severe crushing railroad injuries that occur in civil life. Out of the 22 deaths from shock in the 100 fatal cases, only 8 were caused by bullets, and in all of these the cavity of the abdomen had been penetrated by the projectile. In the remainder the injuries were from gunshot, shell, or grape.

CHAPTER III.

ON HÆMORRHAGE AS A PRIMARY SYMPTOM OF GUNSHOT INJURIES.

Fatal primary hæmorrhage in gunshot wounds.—Primary hæmorrhage is one of the local symptoms of gunshot wounds which varies very greatly in degree, not only according to the size and situation of the blood-vessels wounded, but also the manner in which the wounds are inflicted. In some gunshot wounds there is hardly any hæmorrhage of moment, even though primary vessels have been divided; in others the hæmorrhage is to such an extent as of itself to cause speedy death.

Much difference of opinion has been expressed concerning the number of deaths which result after gunshot injuries from primary hæmorrhage on the field of action; and the question of the real proportion of fatal consequences from this cause to deaths from other causes in warfare is still an open one. There is no doubt about the fact that primary hæmorrhage from gunshot wounds, in which large arteries are opened, does not often come within the observation of army surgeons. Out of 4,434 wounds detailed in the British returns of the Crimean war, only 15 wounds of arteries were registered; out of 87,822 wounds tabulated in the United States' Circular No. 6, of 1865, only 44 gunshot wounds of arteries were registered. But these enumerations give but little clue to the true proportion of wounds of large arteries, and the occurrence of primary hæmorrhage on fields of battle. If hæmorrhage ensues from a wound of one of the main arteries at no great distance from the centre of circulation, it must lead to a rapidly fatal result,

and we have no sufficient means of knowing the number of such cases which occur. Surgeons, after an action, are too much occupied with the urgent necessities of the living wounded to spare time for examining the wounds of the dead, in order to verify and establish the proportion in which such accidents occur. Thus many surgeons speak of fatal primary hæmorrhage from gunshot wounds being exceedingly rare, simply because it is not usually met with in military experience; a statement which more close and extended observation might, perhaps, considerably modify. M. Baudens took some pains to solve this question, and, referring to his service in Algeria, remarked he had often found by examination of the dead lying on fields of battle, that death had been due to primary hæmorrhage.

The nature of the projectile affects the occurrence of primary hæmorrhage.—An important distinction, in estimating the liability to primary hæmorrhage in gunshot wounds, arises from the kind of projectile by which a blood-vessel has been opened, whether by a large or a small projectile. If an artery of moderate size, even though it may be an important one, in common with the parts adjoining, has been torn asunder by a solid gunshot, or by a large fragment of shell, the occurrence of hæmorrhage to imperil life undoubtedly is a rare event. The question does not arise when the occurrence of death may be explained by the mere extent, or by the situation, of the injury; but, omitting these cases from consideration, it may perhaps be said that death is scarcely ever caused by projectiles of great weight from simple primary hæmorrhage. If a vessel happen to be completely divided by a small and comparatively light projectile, a small fragment of shell, or a rifle bullet, there may, or may not be, fatal primary hæmorrhage. This will vary according to several circumstances. These circumstances are principally,—the size and situation of the artery; the manner in which the division is effected; the degree of check to the hæmorrhage from nervous depression and shock; and the amount of subsequent movement and disturbance. From the nature of things hæmorrhage will more constantly occur from a partially divided artery, and must always wear a more serious aspect than when it takes place from one completely divided.

Primary hæmorrhage in wounds by large projectiles.—Ordinarily, so far as the wounds by heavy projectiles are concerned, when large arteries have been divided, the primary hæmorrhage is comparatively small in quantity and of short duration,—a sudden flow at the moment of injury, and no more. When a part of the body is carried away by a heavy shot or piece of shell, the divided arteries are generally observed to be in the same state as they are found to be when a limb is torn off by machinery. The lacerated ends of the middle and inner coats of the artery are retracted within the outer cellular coat; the calibre of the vessel is diminished and

tapers to a point near the line of division; it has become plugged within by coagulum; and the cellulo-fibrous investing sheath, and the clot which combines with it, form on the outside an additional support and restraint against hæmorrhage.[4] When large arteries are torn across, and their hæmorrhage is thus spontaneously prevented, they are seldom withdrawn so far but that their ends may be seen protruding and pulsating among the mass of injured structures; yet, though the impulse may appear very powerful, further hæmorrhage is rarely met with from such wounds.

My eminent friend Baron Larrey has recorded an instructive case illustrative of this fact. It occurred at the siege of Antwerp. An artilleryman had his legs separated as he was standing near a gun which he was about to sponge, when he was struck in both thighs by a large fragment of a shell. It passed from behind forward. All the soft parts of the posterior and inner aspects of the middle third of each thigh were torn away, but neither femur was broken. The two femoral arteries were completely divided, and were seen in the middle of the torn flesh, but there was no flow of blood. The pulsation of each artery was very perceptible in the upper torn end down to three or four lines from its extremity, where on pressure it appeared to be plugged up. Surgeon-Major Forget, under whose care the case fell, feared to leave the arteries thus exposed without any artificial control, and applied a ligature to each; but there can be little doubt the ligatures were unnecessary—no hæmorrhage would have taken place. Baron Larrey mentions that after the ligatures were applied, he cut off the ends of the lacerated vessels, and on splitting them up found just the same appearances as may be seen in an artery the bleeding of which has been stopped by torsion. Just before the final assault on the Redan, as the men of the regiment I was serving with were moving through the works, a gunshot passed along the trench and carried away the right arms of three men. There was no hæmorrhage of account from any one of them at the time the wounds occurred. I have seen a leg taken off above the knee by a gunshot, without any important loss of arterial blood; and my own experience would lead me to doubt if fatal primary hæmorrhage ever does occur, when the injury consists of complete removal of a limb by gunshot.

The following case, the notes of which have been given to me by Inspector-General Taylor, C.B., in whose practice it occurred, when surgeon of the 29th Regiment, is particularly interesting and instructive as regards the subject. At the battle of Ferozeshah on December 21, 1845, Sergeant Reitchie was struck by a round shot in the left axilla. It divided the artery, and smashed the adjoining structures, so that the arm only remained attached to the trunk by a portion of the deltoid muscle and the integuments covering it. The wounded sergeant lay on the field, without attention of any

kind that night, all the next day, and until the evening of the following day, the 23rd. On the 24th he was removed in a jolting hackery (a country cart without springs) to Ferozepore, and then amputation at the shoulder was performed, the flap being taken from the available soft parts. No hæmorrhage had taken place, and not a single ligature was required or used in the amputation, although two-thirds of the face of the stump consisted of the surface left by the passage of the shot. The wound healed favourably, and the sergeant was employed for many years afterwards in a staff situation.

Primary hæmorrhage in wounds by small projectiles.—In considering the subject of hæmorrhage in wounds caused by bullets, the fact of the frequent escapes of arteries from division, even when these projectiles have travelled directly in their course, forces itself upon the attention. It comparatively rarely happens, indeed, that the surgeon sees any of the larger arteries cut across by rifle bullets. The lax cellular connections of these vessels; the smallness of their diameters in comparison with their length; the elasticity as well as toughness of the tissues forming their coats; the fluidity of their contents; and, in consequence of all these conditions, the extreme readiness with which they slip aside under pressure, are circumstances which favour the escape of these important structures when they are subjected to imminent danger of injury from the passage of a bullet in their direction. Repeated examples have occurred of musket bullets passing through parts of the body in the exact situation of important arteries, without wounding them: so that they must have been pushed aside by the missiles, or they could not have escaped division. A young officer was under my care in the Crimea in whose case a bullet passed through the neck from side to side behind the larynx. From the course it took the carotid arteries must have been pushed aside to have escaped injury. There is in the museum at Netley a preparation of part of the femoral vessels taken from a soldier who was wounded in the thigh at Toulouse by a musket bullet. The projectile penetrated the sheath of the vessels, passed between the artery and the vein, but did not open either vessel. So close was the ball, and such contusion and injury to the vasa vasorum were produced, that the artery became plugged by coagulum and obliterated. This case has been fully described by Mr. Guthrie, as well as a similar one in which the bullet passed between the popliteal artery and vein of a soldier without opening either.[5] I have met with several examples of obliteration of vessels at Chatham and Netley among men who have survived and been invalided for gunshot wounds. The obvious explanation in all these cases was that the trunks higher up had been pushed aside and contused by the projectiles at the original seat of injury.

The position of a limb or artery, when struck, may prevent the

escape, which might otherwise have taken place, of a blood-vessel from division. I had the opportunity of examining the fatal wound of Captain Hedley Vicars of the 97th Regiment, whose death led to so much interest in England. He had been struck by a bullet which had penetrated the right axilla, and divided the axillary artery. His arm had apparently been stretched out when he received the injury, while he was in the act of holding up his sword. The night was very dark, the distance from the place where the sortie took place in which he was wounded to camp was more than a mile and a half, and he sank from hæmorrhage while being carried up.

Collision of angular projectiles with blood-vessels.—It is not only when small projectiles with smooth and rounded surfaces cross the paths of arteries that they exhibit a remarkable facility for moving aside and escaping division. Occasional instances are presented of irregularly shaped missiles, such as fragments of shells, passing in the course of arteries without opening them, so that the vessels must have yielded to the pressure and slipped aside in the same way as so often happens with bullets. In the Crimea a shell fragment traversed the ham of a soldier of the 56th Regiment between the artery and the bone. The artery was thrust back out of the way and remained uninjured. The man afterwards died, but from another cause. A similar wound occurred in the case of a soldier of the 9th Regiment. In this instance the piece of shell scooped away some of the bone. This man recovered. In another instance, a large shell fragment passed through the upper third of the thigh, between the artery and the bone, without injuring either, recovery following.[6] These, however, must be regarded as exceptional cases. Experience in military surgery sufficiently shows that fragments of shells, with linear and jagged edges, are likely, as might well be expected, to cause division of arteries, when the same vessels would probably escape were they brought into collision with projectiles possessing smooth and convex surfaces. The remark applies equally to splinters of wood, fragments of stone, and all other missiles of the indirect kind with sharp and angular outlines.

Wounds of large arterial trunks.—When the principal arterial trunks of the body are so brought into opposition with small projectiles, whatever their form, that division does take place, hæmorrhage may be regarded as inevitable, and in the field it must in almost every instance be of a speedily fatal character. If it be such a vessel as the subclavian, the carotid, the femoral near the groin, and still more surely if it be one of the larger divisions within the body, the hæmorrhage will be so rapid and persistent that death will take place within a few minutes, or very nearly as quickly as if the aorta itself had been divided. The force of the arterial current is in excess of the means of resistance with which

the divided vessel is endowed. Some wonderful accidents have been recorded in which even the aorta itself has been opened by bullets, and yet life has not been extinguished until hours, and even days, have elapsed; but these have been so few as only to prove the general rule of their immediate fatality. Probably there has never been a more wonderful instance of such an event than one which is illustrated by a preparation in the Hunterian Museum[7] of the ascending aorta of a seaman, in a wound of which, an inch or so above the valves, a spherical bullet is lodged. The presence of the bullet had served so far to check the hæmorrhage as to enable the man to live three days after he had been shot.

Wounds of vascular branches.—If, however, a branch vessel be wounded in action, the hæmorrhage may be only temporary in character, being checked by the usual natural means, and time may be given for surgical proceedings afterwards to effect its complete arrest, if the natural processes have not sufficed for the purpose. Individual cases will be modified by the force with which the projectile cleaves the vessel asunder, the shape of the part presented to the vessel, whether obtuse or with a flattened out sharp edge, the nature of the parts behind the vessel, and other circumstances. As a general rule the more nearly the mode of division approaches to that by incision, the more probable will be the occurrence of primary hæmorrhage; the more it approaches to division by crushing and rending, the less probable will be its occurrence.

Thirst of wounded men.—Men wounded in action generally suffer much from thirst, but thirst can hardly be described as a symptom of gunshot wounds in general. When the wounds have been followed by hæmorrhage, thirst will be induced as one of the results of the loss of blood. In the majority of instances, however, the urgent thirst of men lying wounded on fields of battle is in a great measure due to causes which have preceded the infliction of their wounds. In summer campaigns, long and hurried marches under a hot sun on dusty roads; constriction of the body by accoutrements while sustaining a heavy weight, causing rapid exhalation of fluid from the lungs and skin; broken sleep from night duties, inducing a state of semi-pyrexia; not unfrequently the issue of salt rations, with absence of succulent fruits or vegetables; excitement of the nervous system arising from the circumstances and dangers of approaching battle; and the still higher excitement in the conflict itself, stirring the passions, hurrying the circulation, increasing restlessness, and exalting the sensibility; these are the circumstances which have not unfrequently acted as exciting causes, singly or combined, of the painful and intense thirst from which men wounded in action so generally suffer. The irritation and pain of many wounds, especially those in which bones have been fractured, help to intensify the feeling of thirst; and all wounds, if the men are left long enough on the ground for them to become

inflamed, exaggerate the torture arising from this symptom when it remains unrelieved.

Aggravation of thirst caused by hæmorrhage.—Considering the circumstances which have just been named, and the increased urgency of the demand for a supply of fluid to the system induced by them, it can readily be understood how a wound attended by loss of blood, *i.e.* by a direct abstraction of some of the fluids circulating in the vessels of the body, must increase the want felt of a fresh supply to a vast extent; and how it happens, when the drain from the system goes on through continued hæmorrhage, that the thirst of the dying soldier becomes a real agony.

Circumstances which modify the thirst of wounded men.—The extent to which thirst is excited among men suffering from gunshot wounds is not constant; it varies not only according to the extent to which the exciting causes before mentioned have been in operation, but is also affected by other circumstances. It may be moderated by the state of the atmosphere, as when it is damp, foggy and cold, for some of the conditions which excite thirst are then wanting. Personal peculiarities of constitution, and personal habits in respect to the amount and kinds of drink usually taken, will influence the extent to which the desire for fluid is experienced. But, though the craving for water may vary in degree in different individuals, the craving itself is still one of the most prevailing and urgent sources of suffering among wounded men on battle-fields; and no more charitable or serviceable action can be performed than ministering to its relief when men are left lying on the ground from want of opportunities for their removal, and no one of the miseries experienced by sufferers in this condition, on being relieved, conveys such intense satisfaction, or calls forth such manifestations of gratitude, as the relief of thirst.

CHAPTER IV.

LODGEMENT OF PROJECTILES AND OTHER FOREIGN BODIES IN GUNSHOT WOUNDS.

Lodgement of foreign bodies in general.—When a bullet, a fragment of shell, a piece of some indirect projectile, or any foreign body carried by a projectile, has entered a part of the body and has not passed out again, whether its situation be known or unknown, the foreign body is usually spoken of as having 'lodged.' Lodgement may occur in any structure, cavity, or viscus of the body. It is chiefly a result of low rate of speed in projectiles; but its occurrence is materially assisted by irregularities of outline, obtuse and flattened form, low amount of density, and other physical conditions peculiar

to the substance which has entered. From these causes lodgement happens, in more frequent proportion, with such articles as are carried into the body by projectiles, and with projectiles of the indirect than with those of the direct kind. It has been already noticed that this particular complication of gunshot injuries, lodgement, or the presence of metallic and other foreign bodies, in the midst of tissues which have been severely contused and torn, is one feature among others which helps to separate them, as a class, from ordinary contused and lacerated wounds, as it equally does from incised and stabbing wounds.

Lodgement of bullets.—When the smooth-bore musket was in common use, lodgement of musket bullets was of very frequent occurrence. This arose principally from the spherical bullet not having sufficient velocity, at the distances at which soldiers were commonly hit, to force its passage directly through the parts opposed to it; but was also greatly due to its liability, owing to causes elsewhere explained, to be deflected from a direct line, and consequently to take a tortuous and prolonged course within the body. Hence a round ball might be prevented from effecting an exit by structures far away from those near its point of entrance. Modern conoidal rifle bullets are not likely to lodge at the same distances from the point of fire as the former round projectiles were accustomed to lodge. Their greater force, and mode of flight, enable them to pass through most parts of the body at such distances. But at greater distances, when their velocity has become nearly expended, or materially lessened, by length of range, as happens in battles and sieges where the combatants are far apart, their passage is resisted by the opposing tissues, and their exit by the dense fascia and elastic skin, in the same way that the passage and exit of the old projectiles were at shorter distances. Their lodgement may also take place within shorter range, when they have happened to strike, perhaps pass through some object, before entering the body; or after entering, on their coming into collision with strong tendons or bones; or when, from peculiarity in the posture of the person wounded, the projectile having had force enough to traverse one part of the body, afterwards enters another part of the body from which it has no longer force enough to enable it to escape. Altogether it may be said that the fact of lodgement occurring is not so much changed by the use of modern rifle projectiles, as the distance from the point of discharge at which under ordinary circumstances it is likely to occur.

Lodgement of conoidal bullets.—It is not often that a knowledge of the proportion in which bullets have lodged in a given number of patients can be obtained, nor is it a matter of practical importance to have the information, for the proportion must vary continually with the distances at which the combatants are separated from each other. As an example of experience on this head, how-

ever, in respect to modern projectiles, it may be mentioned that Professor Socin has recorded the fact that out of 727 gunshot wounds observed in the hospital at Carlsruhe, half of which came direct from the battles of Weissenburg and Spicheren, and the others from various engagements in France, the bullets had lodged in 130 instances, or about 18 per cent.[8]

Although the figures quoted show that the proportion in which modern elongated bullets lodge in gunshot wounds is still considerable, there can hardly be any doubt about the proportion being less than it was when the spherical obtuse-fronted bullets were in common use. The difference probably is not so important as it might at first be supposed to be, for the lodgement of other substances equally deleterious is still so constant a concomitant of gunshot wounds, as to make the subject of the lodgement of foreign bodies one which requires as much attention on the part of army surgeons as ever it did. It influences questions of treatment, and has a material bearing on the progress and ultimate results of gunshot injuries.

The kinds of foreign bodies which are liable to lodge in gunshot wounds among soldiers on active service are very numerous.

Lodgement of foreign bodies derived from a soldier's person.— Besides the projectiles themselves, a variety of substances which they are apt to carry along with them into wounds, are liable to become lodged also. These include portions of woollen clothing and of linen underclothing; fragments of some of the articles comprising the field-kits of soldiers, and carried in their knapsacks; of other things, coins, keys, watches, &c., carried in their pockets; bits of leather from belts, shoes, pouches, &c.: buttons, nails from boots, buckles, and other metallic substances belonging to soldiers' uniforms;[9] splinters of their water canteens, and many other such articles. In short, fragments of anything soldiers happen to be wearing or carrying at the time of being hit, may be found lodging in the tracks of the projectiles.

In addition to these foreign bodies from without, wounds are liable to be complicated by the lodgement of a variety of substances derived from the patient's body itself, which act as foreign bodies, and are indeed in all respects foreign bodies, so far as the new situation in which they are placed is concerned. A piece of integument, a fragment of bone, shreds of contused tissues, detached from their normal positions and carried by missiles into and among wounded structures, are as much foreign bodies as splinters of wood and metal. They act quite as injuriously, from their nature, indeed, often more injuriously, than inorganic foreign bodies in like circumstances. A splinter of bone carried from a broken rib, and lodging in a wound of a lung, adds immensely to the gravity of the case; a detached piece of muscle or tendon, driven into the

midst of living tissues, becomes a focus of irritation, which may lead to troublesome, or even serious results.

Positions of lodged foreign bodies.—When a bullet strikes a man point blank, and happens to tear away a fragment of some pliable substance, such as cloth or linen, so that both become lodged, they may be expected to be found lying together at the bottom of the wound: the fragment like a cap in front, the bullet behind. This is seen to happen both when the bullet stops in the cancellated end of a bone, and when its further progress is arrested by some of the soft tissues of the body. If the projectile fracture the shaft of a bone, the piece of cloth or linen accompanying it will be usually caught by some of the fragments and be found lying among them. But if the bullet strike the body slantingly, especially if its course within the body be a long one, then, as it passes on, it usually leaves a soft substance of this kind behind in some part of its track. The diminution in width of the most recent rifle projectiles has had a tendency to lessen the chances of lodgement of portions of clothing. But the reports of cases of wounds inflicted by the narrow Chassepôt bullet have sufficiently shown that the occurrence is still a very frequent one. The lodged fragments of cloth may be less in size than they were with former bullets, but the complication hardly appears to be less common. Professor Socin observed lodgement of bits of shirt and uniform to be so common among the cases of gunshot wounds at Carlsruhe, both among the wounds with two openings as well as those with only one opening, that he was led to believe the quicker healing of wounds in those parts of the body which are usually uncovered by clothes to be partly due to their freedom from such textile fragments being carried into them.

When the substance driven before the bullet is a hard one, like a button from the uniform, the bullet, supposing it to retain its original form, generally forces the substance to take a position on one side of the main track, while it passes on itself, and finds a more distant seat of lodgement, or makes its way out of the body altogether. The force of the bullet is partly expended in striking and driving in the piece of metal, but it still retains sufficient momentum to effect its escape or to reach a deeper or more distant place of lodgement. Its figure and density, too, are more favourable for effecting a passage, than are those of most of the substances liable to enter the body with it. The latter quickly lose the velocity impressed upon them, and are easily arrested by some of the surrounding tissues. It is of practical value to remember that, when bullets which have not become deformed, and hard substances driven in by them, remain lodged among the soft tissues of the body, they are only in exceptional cases found lying together in the same part of the wound, owing to the differences of form and in

the amount of force with which the foreign bodies are severally impressed.

Such things as watches, knives, pencil-cases, seals, and other articles of irregular shapes and varied composition are liable to be broken up into many fragments on being struck by bullets, and these fragments seriously complicate the wounds from their angular forms and liability to be driven in various directions. A case of gunshot wound in the thigh, related by Ravaton, has been often quoted, in which the healing was delayed by the fragments of a silver seal and a copper key, which the patient had in his pocket at the time he was hit. The seal had a cornelian stone, which was divided into thirteen small fragments, while the silver part was broken into three pieces. The musket ball by which the injury was inflicted was at once extracted, but it was not till three months afterwards that the other foreign bodies were removed. The number of fragments into which the articles in the pocket were broken, in this instance, is far exceeded in one which occurred during the late war of the Rebellion in the United States.[10] A soldier was struck in the thigh by a conoidal bullet at Mine Run on November 27, 1863. The missile shattered two knives which were in the man's pocket and carried the fragments with itself, also cut into pieces, into the man's thigh. In the account of the case it is stated that one hundred fragments of the knives and four of the bullet were removed in the field hospital. The patient was removed to the hospital at Washington on December 4, and died of pyæmia on December 22, 1863. Seven other fragments of brass, steel, and bone, including the iron back-spring and one brass side of one of the pocket knives were removed after death. Coins struck in a similar manner generally remain entire, though more or less bent and deformed. Serrier, quoting from M. Laroche,[11] refers to the case of a person who had twenty Napoleons in his pocket at the time he was wounded. The coins were struck by the bullet in its course, and were all driven into the cavity of the abdomen. They were found to be entire, but all more or less deformed. Dr. Hennen has described a case in which not only some coins—viz. two five-franc pieces and two copper coins—were carried into an officer's thigh by a large projectile, but also the trouser pocket of coarse linen in which the coins were contained. The whole were deeply imbedded in the vastus externus muscle. It was not until after suppuration was established that these foreign bodies were discovered. Dr. Chenu, in his account of the Italian Campaign of 1859, describes a severe case of bullet wound of the right groin with fracture of the ilium. After one month's treatment two fragments of the bullet and a medal, and after three months a sou much bent by the projectile, were brought away. The wound then healed. He also relates that during the siege of Paris (1870–71) a fragment of shell detached from a soldier's tunic two brass buttons, both of

which were projected violently into the left orbit, and destroyed the eye without injuring the eyelids. In another case a bullet struck a button on the left side of a soldier's tunic, detached it together with a piece of cloth, fractured the sternum and some ribs, and lodged beneath the wall of the chest on the right side. In this instance the bullet and button were extracted together; the bullet being impressed with the number of the regiment borne on the button. He also gives an instance of a knife being broken into fragments by a bullet during the siege, and carried into the thigh; another of a pair of scissors broken in a similar manner; a third of a nail from a boot lodging in the metatarso-phalangeal joint of the great toe.[12] Dr. Socin, in his surgical observations collected at Carlsruhe during the same war, refers to a case in which three French sous much bent, and two waistcoat buttons which a wounded soldier had carried in his trouser pocket, were extracted, at different times in the course of three months, from the man's thigh. He also describes a remarkable wound in which a bullet and button entered together. Singularly enough, in this instance, a Chassepot bullet made a complete hole through the upper button of the soldier's uniform coat, but became fixed when halfway through the perforation. The leaden bullet penetrated with the brass button equatorially surrounding it, and the two were extracted, still in the same relation to each other, from a deep wound in the neck.[13]

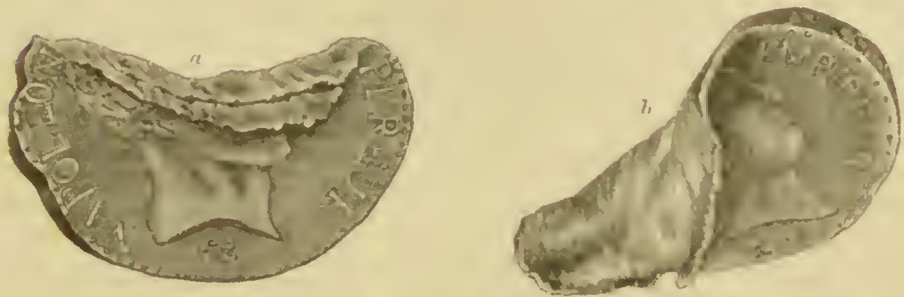
Wounds on parts of the body usually uncovered, such as the face, neck, and hands, have, as a general rule, the advantage of being free from the risk of such complications as lodgement of the substances which have just been mentioned. But they are not free from the lodgement of the natural coverings of the parts, such as the hair of the beard, whiskers, or moustache on the face, and these are often carried deeply into wounds and sometimes give rise to much irritation. Neither are they of course free from the lodgement of extrinsic substances which may have been displaced by the projectile from the neighbourhood of the wounded part.

Lodgement of foreign bodies derived from surrounding objects.—It may be readily understood that, just as substances derived from the person of the wounded soldier himself may become lodged, so others, derived from anything which may have happened to be near to him at the instant of being hit, may become lodged also. Such articles may either enter independently as indirect projectiles, or may accompany the primary projectiles by which they have been detached from their original position. Sometimes parts of the bodies of wounded men are thus made to act as projectiles, and to inflict wounds on other men. Such fragments usually become lodged in the wounds made by them. In a severe wound of the face which occurred to a soldier in the Crimea, the surgeon was at first puzzled by what appeared to be a strange displacement

of a part of the upper jaw. After closer examination and obtaining a clearer view by the removal of clot, it was found that a piece of the jaw of another man had been driven into the palate, and impacted there. It had come from a soldier whose head had been shattered by a round shot while standing by his side in the battery. Among other such cases which occurred during the Crimean War was one of a double tooth of a comrade being found imbedded in the globe of a wounded soldier's eye; and another where a portion of a comrade's skull was removed from between the eyelids of a soldier. Hennen has related a case in which, after amputation of the arm of an officer for gangrene supervening on a gunshot wound, the olecranon and part of the shaft of the ulna of another man were found embedded in the tissues in front of the elbow.[14] During the Crimean War an officer of the 97th Regiment came under the care of my friend, Surgeon-Major Porter, with a long lacerated wound of the front of the thigh. He attributed it to a shell having exploded and caused him to wound himself with a ramrod that he was carrying in his hand. A fortnight afterwards Surgeon Porter extracted by incision from the back of the thigh, where a large abscess had formed, a long fragment of the thigh bone of another man who had been killed by the shell in front of the officer. This splinter had caused the laceration, and not the ramrod, as the patient had supposed. When two or more men are wounded by the same missile, they are very likely to be struck in corresponding parts of the body. Thus, I have known, as before mentioned, the right arms of three men standing behind each other, carried off by the same shot, and the same bullet fracture the lower jaws of two men standing side by side. So, if a fragment of bone from one man lodges in the body of another man, for a similar reason it naturally occurs that the lodged fragment has usually been detached from a corresponding region with that in which it becomes lodged. This may sometimes be the source of much puzzle to a surgeon, but the recollection of its probable occurrence will generally prevent a mistake in diagnosis, which might otherwise happen. The same observation applies to articles of equipment and other things carried on the persons of soldiers. There was, until lately, when some one stole it, presumably for the small amount of silver it contained, a curious relic in the Museum of the Army Medical Department at Netley, which may be referred to in further illustration of the facts just stated. Dr. Hennen extracted from the thigh of a Hanoverian soldier, on the third day after his admission into hospital, two five-franc pieces and a copper coin. The man declared he had had no money about him previously to the injury, nor even a trouser pocket capable of containing any. The absence of the pocket was proved to be correct. The coins must have been carried from the pocket of another soldier, who had stood before him in the ranks, and had been hit

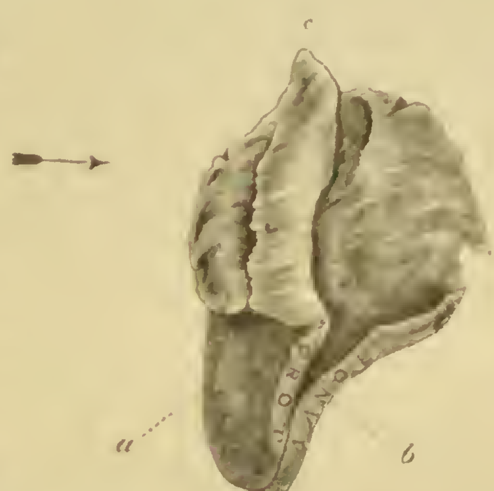
by the same grape shot. The history of the case has been fully described by Dr. Hennen,[15] who presented the mutilated silver coins to Sir J. McGrigor for preservation in the Army Medical Museum. As, however, they have disappeared, and I happen to possess some drawings of them which had been done for me by my friend Dr.

FIG. 26.



(a) (b) Pocket coins defaced by a passing shot (*See* history in text).

Gillespie, I have inserted illustrations of them. The great force with which shot have struck is often manifested in a very marked manner by the effects produced on metallic and other resisting substances carried upon the persons of soldiers. In the present instance the two five-franc pieces seem to have been acted upon by the shot almost as if they had been so much wax. Part of the silver was completely carried away, and the exposed edges of the two coins where they were cut were pressed out, curved, and made to fit into one another exactly. And this was done while they were lying against a man's thigh!



(c) Sketch showing the relative positions of the two coins after being struck.

Lodgement of scales of lead from bullets.—When bullets are broken into several fragments, one or more of them usually remain lodged. When spherical bullets were in common use, although the bullet might appear to remain entire when extracted, or to have passed out undivided, a small superficial layer of the metal, like a portion of one of the concentric coats of an onion, was often found to have become detached from it, and to have remained lodging at or near the site of injury. I was once applied to by a discharged soldier suffering from some trouble-

some granulations at the bottom of the left orbit. The globe of the eye had been destroyed nearly two years before by a musket bullet, shot from above, which, after traversing the orbit had descended, and was excised from the right side of the neck. While examining the granulations on the stump of the eye with a probe, it came into contact with a hard substance which further examination showed to be a point of lead. This proved to be a scale stripped from the bullet which had caused the original wound, and was about one-third of the sphere in dimensions. It retained the curved form of the bullet from which it had been detached. I have also removed a similar scale of lead from a deep wound in the neck. The fragment was lying close to the bullet from which it had become separated. Similar sections are occasionally separated from cylindro-conoidal as well as from round bullets. An officer of the 41st Regiment was wounded in the Crimea by a conoidal bullet which passed through the forearm. Secondary hæmorrhage occurred on the eleventh day after amputation had been performed; the stump was then opened and examined, and a scale of the bullet about the size of a bent sixpence was found to have been the source of the hæmorrhage. A soldier of the 19th Regiment was wounded in the loin by a cylindro-conoidal bullet which was discharged per anum. Four years afterwards this man died from albuminuria in Guy's Hospital, and at the post-mortem examination a small scale from the bullet was found fixed in the spleen.

Lodgement of projectiles of large size.—The projectiles and most of the substances hitherto mentioned as being liable to become lodged have been of moderate size. But very large fragments of shells are also apt to bury themselves in wounds, and such heavy projectiles as grape shot, and even the smaller kinds of gun shot, occasionally lodge in them. Fragments of shell, however, are the heavy projectiles which are most frequently found lodged in wounds. Dr. Grellois, in his account of the late siege of Metz,[16] states that 'the number of fragments of shells, large and small, extracted from wounds in our ambulances was immense.'

Lodged foreign bodies often overlooked.—It has been a matter of such frequent experience that foreign bodies, when thus lodged, may remain for long periods, not only days but weeks, undiscovered, and this, not only when they happen to have penetrated deeply among muscular tissues, or when they have travelled so circuitously and far from the aperture of entrance as not to be readily discoverable, but under circumstances when it might be expected the lodgement would be at once noticed, that it becomes important to put military surgeons on their guard respecting the occurrence. The fact may be accounted for in some of the several ways mentioned in the following paragraph.

Causes which assist the concealment of foreign bodies in wounds, with examples.—Sometimes the appearance of the seat of injury

is liable to throw the surgeon off his guard. Penetrating fragments of shells, if projected edgeways, almost invariably lodge. In these cases the external appearance of the wound seldom indicates to the observer either the lodgement, or the size, of the body which has caused the injury. At an early period of the battle of the Alma, a piece of shell which proved to be about 4 lbs. in weight lodged in the buttock of a soldier of the 19th Regiment. It was so bulky that to extract it I had to make an incision as long again as the existing opening. In this instance the concave aspect of the fragment, evidently by the nature of the curve and its thickness a portion of a very large shell, had adapted itself to the parts lying beneath, while its convex surface so agreed with the natural roundness of the parts above, that it would have been impossible to have arrived at a knowledge of its presence, from any change in the external appearance of the parts. It was only by examination of the wound by the finger that information of the lodgement was obtained. Such fragments become very firmly impacted among the fibres of the tissues in which they lodge, and the effused blood fills up inequalities, and rounds off edges that might otherwise show themselves prominently, so that, without due care, their presence is not unlikely to be overlooked on first examination. The general symptoms that might indicate the presence of such a heavy substance are masked by the symptoms of the wound itself. Dr. Macleod, of Glasgow, mentions that he saw a case at Scutari in which a piece of shell weighing 3 lbs. was extracted from the hip of a man wounded at the Alma, which had been overlooked for a couple of months. Probably here also the shape of the fragment agreed with the natural contour of the part in which it was lodged.

The disappearance of the foreign body in some of the natural cavities of the body, together with the absence of any prominent indications of its presence, owing to facilities for the escape of purulent discharges by some of the natural outlets, may lead the surgeon to remain unaware of its lodgement. In the well-known case of Lieutenant Fretz, of the Ceylon Rifles, the descent and lodgement in a cavity above the floor of the nose of the breech-piece and pin of the musket, which had inflicted the wound in his forehead, although weighing nearly three ounces, was not known till about a year after the injury, when the tapering end of the breech-piece and part of the pin made their way through the palate and protruded into the mouth.[17] In the Museum of Military Surgery at Netley there is the iron breech of a fowling-piece, weighing 4 ounces within a few grains, which had lodged in the face of a man, either in the nasal fossa or antrum, for twenty-three and a half years, when the fact of its lodgement was made known by its falling into the pharynx. The fowling-piece had burst, and when the patient was seen by Mr. Giraud, surgeon, of

Faversham, there was an extensive wound over the right orbit, the orbitar plate of the frontal bone was completely broken down, the eye and some brain were protruding at the seat of fracture, but no foreign body was discernible. The wound healed, after considerable sloughing of the brain and other mutilated parts, under simple treatment without leaving any sinus or other indication of a foreign body having lodged in any part of the wound. After the lapse of the period mentioned, nearly twenty-four years, the subject of the wound, whilst in bed, was suddenly seized with a feeling of suffocation and was conscious at the same time that something had fallen into his throat. He started up, instinctively thrust his finger and thumb into his mouth, and then pulled out the breech-piece. As this case has not been hitherto published, I have inserted some further particulars concerning it in the Appendix.[18] Dr. William Keith, of Aberdeen, removed the breech of a burst fowling-piece, weighing 2 ounces 5 drachms, and almost identical in shape with the one just mentioned, four months after the infliction of the original wound. 'It rested against the sphenoid bone in front of the sella tursica with the screw bolt protruding laterally into the bottom of the left orbit.' Dr. Keith states that no suspicion had been awakened in the minds of the surgeons, who had been previously in attendance on the case, as to any foreign body having lodged in the wound. Dr. J. N. Fraser, of Newfoundland, extracted from the right maxillary antrum the breeching of a musket which had lodged there eight years without having been previously discovered or its lodgement suspected, although the patient had been under the care of several surgeons.[19]

Sometimes a surgeon may be diverted from searching for a foreign body by erroneous statements of the patient himself. There is in the Museum at Netley a preparation showing a large amount of new bone surrounding an united fracture of the upper third of the femur. In a hollow within the new bone there is locked up a bullet. It can be seen through some small openings, and can be heard when the bone is shaken. The patient, who was wounded during the Indian Mutiny, declared positively that his wound had been caused by a fragment of shell, and that he had seen the fragment glance off after it had struck him. It was only after the man's death, which occurred a year afterwards, that the fact of a bullet having lodged became known. Dr. Hamilton, of the United States, has recorded the case of a soldier brought to hospital with a bullet wound through the calf of his leg. The man stated that the ball had gone 'clean through.' By means of Nelaton's probe an iron shot, weighing 2 ounces, was discovered in the wound. Another man had a gunshot wound a little above the left ankle joint. The man was told on the field that the bullet had glanced off after inflicting the wound, and was firm in his conviction that it had done so. Three months afterwards exploration by Nelaton's

probe led to the detection of a Minié rifle bullet impacted in the tibia.[20]

Neglect of thorough exploration of the wounds by the surgeons, both at first and subsequently, and an erroneous conviction on the part of the patients that the pain and sense of weight arising from the presence of the foreign bodies were due to the unavoidable effects of the wounds, can alone explain how substances, so obvious to the touch and of such sharp and angular outlines as are mentioned in the following instances, can have been not only undetected in the first instance, but allowed to remain for long periods acting as sources of irritation to the parts among which they were lodged. A strange feature, too, is that such oversights are not unfrequently met with in situations where it could scarcely be expected it would be possible for them to occur.

A private of the 23rd Regiment was wounded at the Alma by a grape shot, which carried away the left testis, entered the perinæum and lodged. The ball was excised from the edge of the right natis on board the transport which took him to Scutari. The orifice of the urethra was grazed as the grape entered the scrotum, but the perinæal portion of the urethra escaped injury. He was two and a half months at Scutari, and then a fortnight at Malta. He left Malta in the 'Cambria,' with the wound still unhealed, and was among those who were attacked by hospital gangrene in that vessel on the way to England. He was admitted into Fort Pitt on January 21, 1855, with the wound in the perinæum still open, but looking healthy. A fortnight afterwards Staff Surgeon Parry, in consequence of matter having collected, incised the perinæum freely, and discovered a splinter of wood four inches in length, and subsequently, two smaller splinters, all of which he removed. They were found to be fragments of the man's water canteen which had been struck by the shot on its passage towards the scrotum. Another soldier was admitted into hospital at Chichester in 1856, with a narrow sinus near the left hip resulting from a gunshot wound. On inserting a probe, it passed deeply among the gluteal muscles and touched some rough body. An incision was made, and a piece of stone, nearly four ounces in weight, removed. This man had received his wound, about twelve months previously, in one of the batteries before Sebastopol, and had been in several hospitals before reaching the dépôt at Chichester.

In March, 1871, a 20-pounder breechloading Armstrong gun was being loaded at Bermuda with a shell, which exploded, and a sergeant, who was directing the charge of the gun, suffered several injuries in consequence. He escaped from being struck by any of the shell fragments, but received several wounds and contusions about the face and forehead from splinters of a wooden rammer, with which the shell was being forced into its chamber at the time it exploded. He was sent as an invalid to Netley on account of

very defective sight; vision of the left eye having been destroyed by the entry of a small splinter of wood, and that of the right eye having been seriously impaired by inflammation consequent on contusion. At Netley a small opening, from which some pus escaped, was observed in the under surface of the tongue near the frænum. On passing a probe, a foreign body was detected, and this, when extracted, proved to be a splinter of wood, in shape like an arrow-head. It was about an inch in length, by a quarter of an inch in thickness, and was cleft into two parts behind. The point which had first entered was sharp; the rest of the piece of wood was split and much jagged. It had lodged in the situation described for twenty-two weeks undiscovered. It is not a little difficult to understand, considering the mobile and sensitive nature of the organ in which it was placed, how the sergeant himself had not been led to suspect its presence. But even a piece of shell, several ounces in weight, has been known to lodge in the front part of the floor of an officer's mouth, and, accessible and obvious as this situation is, to remain undetected until the extension of swelling to neighbouring structures, threatening suffocation, led to further surgical advice being obtained.[21] Special circumstances, such as the entry of two projectiles by the same opening, and a different and distant course being taken by one of them, may readily throw a surgeon off his guard and cause him to fail in discovering them both. An officer of the 19th Regiment was struck in the back by two grape shot during the assault of the Redan on September the 8th, 1855. They both entered near to each other on one side of the dorsal spine. One of them lodged not far from the wound of entrance, and was readily found and extracted. The other was at first supposed to have escaped, as it could not be felt about the back, but on further examination a swelling on the inner side of his right arm led to its detection. It was lying a little below the limits of the axilla, and from this situation I excised it. The thigh of a soldier was fractured in the Crimea, and a bullet extracted. There was only one opening, so that there was no reason for suspecting the presence of another projectile. The patient died at Scutari, and on examination after death, a second bullet was found lodged at the seat of fracture.

When the projectile which has lodged is of large size, and there is much distension of the neighbouring parts, this may be erroneously attributed to natural swelling of the injured and disfigured structures among which the foreign body is lying. In some cases it is probable that the fact of much of the substance of the natural tissues being smashed to pulp and reduced in bulk by great compression at the first entry of the projectile, may prevent there being any great amount of swelling, simply because the projectile occupies the place of the anatomical structures it has forced aside. In addition, the great pain of some wounds, together with the increase

of this pain on pressure or movement of the parts, and the consequent urgent desire of the patients to be interfered with as little as possible, may tend to prevent surgeons from making that complete tactile examination which would otherwise prove the means of detecting lodgement in some instances. It seems extraordinary, however, that the mere weight of large iron missiles should not inevitably, at once, cause their presence to be ascertained.

In the Italian campaign of 1859 the lodgement of a gunshot weighing 2,750 grammes (upwards of 6 lbs.) which had struck the shoulder, and fractured the upper part of the humerus of General Auger, of the Artillery, was not discovered until the moment when amputation at the shoulder was being performed, and the knife came into contact with the metal shot. He was wounded at Solferino on the morning of June 24, and the operation was not performed until the 26th. The shot was found impacted between the subscapular fossa and ribs.[22]

Mr. Guthrie's experience during the Peninsular wars led him to record that 'It was by no means uncommon for such missiles as a grape shot to lodge wholly unknown to the patient, and to be discovered by the surgeon at a subsequent period, when much time had been lost, and misery endured.' The same distinguished surgeon mentions a case in which a ball weighing 8 lbs. was not discovered till the operation of amputating the thigh in which it had been lodged was being performed. Baron Larrey describes a similar case. A gunner had his femur fractured by a ball, which, according to the man's own description, had struck another artilleryman by his side after he himself had been struck by it. On his being brought to the hospital, no one doubted that the shot, after fracturing his limb, had glanced off; but, upon amputation, the ball, weighing 5 lbs., was found in the hollow of the thigh towards the groin. The wound of entrance was on the outside of the thigh, and the ball had not only fractured, but had turned round the bone. Dr. Hennen explains the occurrence of large masses of metal lodging among muscles without betraying their presence through their bulk, by the opening of entrance being so frequently smaller than the projectile, and he remarks that he had extracted a grape-shot through an orifice, which, before incising it, was not a fourth part of the diameter of the ball. I have already referred to the same thing happening with lodged fragments of shell. A case related by M. Armand, one of the surgeons attached to the French Imperial Guard in the Crimea, confirms the occasional occurrence of the very small opening by a grape-shot mentioned by Dr. Hennen. A soldier was brought to the ambulance, after the capture of the Mamelon Vert, with his left thigh wounded. An opening, such as might be made by a large musket ball, was found on the outside of the limb. There was no second opening. A large swelling was detected in the popliteal space, without any external mark of

injury, and without much pain on pressure. An incision was made, and an enormous grape-shot extracted. It had glanced round the femur without breaking it. M. Armand observed that the character of the wound alone would not have led one to suppose that any missile had lodged, and certainly no one would have suspected from its appearance that a projectile of such a size as a grape-shot had been the cause of it.

Among the records of the Crimean war is the case of a soldier of the 1st Royals, who was wounded in the face by a grape-shot weighing 1 lb. 2 ozs. The ball lodged at the back of the pharynx, and escaped observation for three weeks. Dr. Chenu has mentioned two cases which occurred during the Italian war of 1859, in which grape-shot were lodged near the ankle joint. In one case the shot was retained one month, in the other two months.[23]

Were it not for the repeated experience of such instances, it would be deemed almost impossible that foreign substances of such weight and size could remain in the body, and often in superficial parts of it, without the knowledge of the patient, even if they happened to escape detection by the surgeon.

Effects of lodged foreign bodies on the early stages of wounds.— The presence of foreign bodies in wounds in their early stages mostly gives rise to irritation, followed by efforts on the part of the living tissues to rid themselves of the offending substances which materially interfere with the healing process. The degree of irritation set up generally varies according to the size, weight, and nature of the foreign bodies lodged, the organ or part of the organ in which they are situated, the extent to which the effect of their presence is aggravated by movements within the body or by pressure from without, and by the state of health of the patient. But the lodgement of a foreign substance, even one of the least irritating kind, such as a small bullet with a smooth surface, may give rise to pain and other troublesome symptoms from the first in any part of the body, although the wound of entrance may gradually become healed over it. The protracted pain and other evils which may be induced from the lodgement of a musket bullet in a comparatively unimportant region of the body are well shown in a case which I have described at page 468 of the volume of Army Medical Reports published in the year 1863. The consequences are occasionally rendered more serious, when particular anatomical structures of the body are pressed upon by such substances. Thus tetanus has sometimes appeared to be due to the irritation of nerves by foreign bodies which have been lying in contact with them, particularly when the nerves have been previously injured; and hæmorrhage has occurred through ulceration when they have been exerting pressure upon blood-vessels.

When the lodged foreign body is large and heavy, its effect upon the parts over which it is lying becomes increasingly dele-

terious, in proportion to the time it remains unremoved. It directly adds to the injury which has been originally inflicted, by the mere influence of its bulk and weight on the weakened structures against which it presses; and it interferes with the reparative processes, which might otherwise be instituted, by impeding the neighbouring circulation. The prolonged lodgement of the gun shot among the contused coverings of the chest, in the case of General Auger, noticed at page 169, was partly the cause of the fatal gangrene which followed the amputation after that officer's injuries.

The remote consequences of the lodgement of foreign bodies in wounds will be discussed further on.

CHAPTER V.

BURNS FROM EXPLODED GUNPOWDER.

Various sources of gunpowder burns.—An occasional primary complication of gunshot injuries is burning of the superficial tissues by the flame of the exploded gunpowder. It is chiefly met with in warfare on occasions of shell-explosions, of injuries from fire-arms when the weapons are discharged close to the persons concerned, of explosion of fougasses, or through the discharge of mines in siege operations and assaults. Burns from exploded gunpowder, also, not unfrequently occur from various accidental causes when troops are on active service. The ignition of cartridges, either in pouches or loose, and the explosion of stores of powder in cases, tumbrils, and powder magazines, occasionally furnish severe examples of such injuries. In civil life, burns from the explosion of gunpowder, from accidents in its manufacture or transport, and from careless dealing with it near flame, are of common occurrence, and the burning often gravely complicates other injuries inflicted at the same moment.

Characters of gunpowder burns.—The characters of the burns from exploded gunpowder are the same, whether they exist as a complication of injuries caused at the same time by solid projectiles, or whether the burns are simply accompanied with the blow, slight or otherwise, from the projected gas, the incandescent state of which gives rise to the burning.

The chief peculiarities of the burns which result from exploded gunpowder arise from the very short duration of time during which the body of the patient is exposed to the fire, and from certain effects of the impulse of the gaseous projectile itself, by which the burns are usually complicated. In other respects—in their gravity according to the extent and depth of the surface burned, and the sites of the injuries; in the character of the inflammation by which

they are succeeded: and in their results—they precisely resemble the burns which are met with in civil practice from the application of solid substances, in a state of combustion, to the surface of the body.

The flame, or 'flash,' of exploded gunpowder, the heat of which is intense, suddenly springs forth with great energy, but almost instantaneously disappears. Were it not so momentary, the high temperature caused by the deflagration of the powder would soon carbonise the parts of the body subjected to it, and destroy life. If the powder which has been the source of it is confined within definite limits, as within a rifle or gun, the emitted flame may act locally over a limited space, according to the nature of the parts exposed to its influence, and the distance at which these parts happen to be from the opening whence the flame has darted forth; but if the exploded powder be comparatively free, as in the instance of a quantity of loose powder, or powder stored in a magazine, becoming ignited, the whole of the body may be at the same moment involved in an atmosphere of flame, though the surface fronting the direction from which the flame has been emitted will be most severely scorched by it. The extent of surface burned, and the severity of the burn, will vary according to the quantity of powder exploded, and the position of the patient in regard to the focus of explosion. The nearer to the source of the flash, the more intense its effect. Much also will depend on the kind and thickness of the coverings worn over the parts of the body exposed to the flash, and by the accident of these coverings being either closely applied to the body, or being loose and open. In some instances the force of the emitted volume of incandescent gas is so applied as to tear away all coverings. When this happens, the clothes are removed, and the parts of the body which were covered by them are subjected to the scorching effects of the flame at one and the same instant. In other cases, some of the clothes are set on fire, and then add to the severity of the burn caused by the flash.

The burning of uncovered parts of the body usually penetrates the epidermis; but in most cases there is not time for it to pass deeper than the surface of the true skin below. The exposure and scorching of the papillary layer of the derma cause the injury to be accompanied with great pain. When persons are exposed to the concentrated effects of the flash of explosions on a large scale, the burning may descend more deeply, and of itself entail speedily fatal consequences. In many of the respects just referred to, burns from the explosion of gunpowder greatly resemble the kinds of burns which are described as being produced by the ignition of coal gas in mines. As a general rule the extent of surface scorched, rather than the depth of structure destroyed, characterises the burns which result from both causes alike; and, in both, the injured surface is liable to be penetrated and blackened, in the one case by smoke and

particles of gunpowder, in the other by dust and particles of coal. There is another feature which sometimes increases the hazards of burns from exploded gunpowder. In some instances the action of the flame is not confined to the external parts of the body; the symptoms occasionally show that incandescent gas has passed down the throat and into the air passages. Perhaps this may occur when the act of inspiration happens to take place at the same instant as the emission of the flame. The fluids with which the lining surfaces of these internal organs are lubricated seem to act, however, to a great extent as a protection against the scorching influence of the heat which is thus suddenly applied, but as suddenly withdrawn; far more so than they do when the same surfaces are subjected to great heat through accidental inhalation of superheated steam.

Concomitants of gunpowder burns.—Among the complications which attend these burns are the effects of the force of the explosion upon the persons of the patients. The nature of the injuries which may result from this source has already been discussed elsewhere. In great explosions all those who are within the sphere of influence of the flame are usually too much injured by the explosive force to come under hospital treatment at all. If the body is not torn asunder, death is almost instantaneous from the combined effects of the general burning of its surface and of the shock of the concussion. When mutilation takes place, and limbs and other parts of bodies are blown to a distance from the centre of explosion, they are generally found scorched and blackened by the burning to which they were exposed at the moment of the explosion. The blackened condition is not altogether due to charring. Even in comparatively slight burns from the explosion of gunpowder, the remains of the singed hair and the burned surface generally are blackened from being impregnated with fine carbon dust that has escaped combustion; and this appearance often gives to the burn, at the first glance, a more serious character than really belongs to it. Sometimes the burned parts emit an odour like that of sulphuretted hydrogen, probably due to a certain amount of sulphide of potassium formed from the explosion of the powder being lodged in the charred and wounded structures. It also usually happens under such circumstances that unignited grains of gunpowder are driven against the surface of the body with such force that many of them lodge in the skin and subcutaneous tissue, thus adding another complication to the burns, and still further increasing the blackened aspect of the injured parts.

CHAPTER VI.

MULTIPLICITY OF WOUNDS.

Frequency with which this complication occurs.—A gunshot wound is liable to be complicated by the occurrence of other wounds or injuries in the same individual, either inflicted simultaneously or within a short period of time after the original wound; and this complication often has a material bearing on the prognosis regarding a case, its treatment, and results. There are not sufficient data for forming an estimate regarding the frequency with which the co-existence of several wounds in the same individual occurs. The forms for statistical returns of wounds usually supplied in armies do not admit of these complications being readily tabulated. A soldier admitted into hospital with several wounds is put down in the numerical returns under the one which appears to be the gravest, and likely to detain him longest under treatment. It has always been regarded as an essential feature of military numerical returns that the number of patients admitted under hospital treatment should be correctly shown, and while the returns are confined to this basis the number of wounds can no more be shown than the extent of surrounding injury and a variety of other circumstances by which the results of the wounds tabulated may be materially influenced. Such information could only be shown in returns specially adapted to the purpose.

Multiple wounds of internal organs.—It is obvious that when bullets pass through the trunk, and especially when they traverse it in an oblique direction, many different visceral organs may be wounded by it in its passage. The same bullet may wound various organs in the cavity of the abdomen, and then, traversing the diaphragm, wound organs in the chest, or passing from the chest may afterwards wound a number of organs in the abdomen. Such cases are usually speedily fatal, but still exceptional instances occur in which life is preserved for a considerable time, and in which it only happens after death that the full extent of the multiplicity of the injuries which have been inflicted is made known. In the convoluted abdominal intestines the number of openings made by a single projectile may destroy all possible chance of life being preserved by any means. On July 31, 1855, Private P. B., of the 19th Regiment, imprudently left the advanced trench of the works before Sebastopol, and went over to the exposed side of the parapet to relieve his bowels. While stooping in the act of defæcation he was hit by a Russian bullet. It entered near the umbilicus, and passed out close to the sacrum. The poor fellow was brought up to the regimental hospital in camp during the night and lingered till

the evening, surviving the wound nineteen hours. On making an examination on the following day, I found that sixteen openings had been made in the small intestines by the bullet. The fact of such an unusual number of duplicatures of the intestine having been perforated, is probably explained by the position the man was in at the time he was shot, and the compression of the intestines by the diaphragm and abdominal muscles in the act of nature in which he was engaged.[24]

It is not, however, so much multiplicity of wounds of internal organs from single bullets which is regarded in the present chapter, as the occurrence of several wounds in different parts of the body from distinct projectiles.

Influence of modern weapons on multiplication of wounds.—It is generally believed that one effect of the introduction of breech-loading arms has been to cause a great number of cases of patients with multiple wounds in warfare; and it is not improbable that the belief is a well-founded one, especially with regard to occasions when small bodies of troops are closely engaged with one another, owing to the rapidity with which these weapons can be discharged. For a similar reason it is not unlikely that the invention of mitraillers has led to frequent infliction of multiple wounds. Men exposed to their almost uninterrupted rain of projectiles can hardly escape from such complications. Dr. Frank, who saw and treated a large number of wounded after the battle of Sedan, and on many other occasions during the Franco-German war of 1870–71, afterwards informed me that he had seen no wounds from the French mitrailleuse. He thought this arose from the fact that a man hit by one mitrailleuse bullet was almost sure to be hit by several others and killed.

Other sources of multiple wounds.—The complication of multiplicity of wounds among soldiers engaged in action with an enemy is, however, not a feature peculiar to modern warfare. It has always existed with more or less frequency in campaigns. Its occurrence was noted in fire from lines of troops armed with the old smooth-bore muskets. The practice of 'double-shotting,' which prevailed in some armies when muzzle-loading arms were in use, added to the liability of this complication. The discharge of canister shot and of grape, and, indeed, of all projectiles combining in themselves a multitude of projectiles of minor size, has also been a fertile source of multiple wounds in individual soldiers; while, in the same way, shells, on being separated into a number of fragments by their bursting charges, and especially if, in addition, they enclose a quantity of bullets like the Shrapnell shells, have also often led, and still lead, to similar results. The fact of men, already disabled by one wound, being again wounded while lying on the ground, or while making their own way or being carried to the rear, has been too often experienced; and the pro-

bability of its occurrence is a source of dreadful apprehension to all wounded men, and one which impels them urgently to seek speedy removal from the scene of conflict. Neither is the production of multiple wounds confined to the action of separate projectiles; they occasionally result from single projectiles when they have sufficient force to enter and pass out of one limb or part of the body, and then to enter and pass through some other limb or part which happens to be placed in a suitable position for the accident to occur.

Fatality of gunshot wounds increased by this complication.—In probably a large proportion of instances in which several wounds are simultaneously inflicted in the same soldier a speedily fatal result ensues, and no record is preserved of them. The wounds which caused death on the field were observed in 118 instances during the last New Zealand War, and it was recorded that more than one wound had been inflicted in many of these fatal cases. The exact number of wounds inflicted was not noted. The observations were made for compiling a table of the regions of the body wounded in men killed outright on the field, and only the wound which was most likely to have caused death in each case was put down in the table.[25]

Recoveries after multiple wounds.—But the occurrence of multiple wounds is not unfrequently mentioned in the histories of particular cases of soldiers who recover, or have to be invalided out of the army on account of them. I am not aware that they have been systematically collected in the history of any campaign. Dr. Chenu, in his history of the Italian Campaign of 1859 (vol. ii. p. 294) gives the histories of a few remarkable cases in which not only several bullet wounds, as many as five and even seven, occurred in the same soldier, but also some in which the patients in addition presented wounds from sabre cuts or bayonet or lance thrusts. In one case a soldier received four bullet wounds at Melignano with two bayonet stabs, viz., a bullet wound of the left arm fracturing the ulna, another of the right side of the chest, a third through the left thigh, a fourth through the right thigh, and two bayonet stabs of the left thigh, and recovered. Another soldier received a bullet-wound of the left thigh, two others in the right thigh, a fourth bullet-wound in the right side, and three bayonet stabs in the right shoulder, arm, and elbow. A third soldier survived after having had five bullet-wounds, viz., one of the right shoulder fracturing the scapula, a second wound at the right axilla fracturing the upper part of the humerus, a third flesh wound of the lower part of the arm, a fourth wound of the left elbow, the bullet making its exit at the middle of the forearm, a fifth of the left hand fracturing the middle finger, and, in addition, a bayonet wound of the right forearm. Another soldier had two bullet wounds of the left leg, producing double fractures of the two bones,

and five wounds in the right arm and right thigh from case shot. An officer had a bullet wound of the left arm with fracture of the humerus, two others of the face and neck, a fourth of the left leg, and a fifth of the right thigh, with fracture of the femur, leading to amputation. Dr. Chenu mentions other instances of soldiers who had been pierced by several bullet wounds, and on whom other injuries had also been inflicted, and who yet made favourable recoveries.

Many examples unhappily occur in war of men, knocked over by gunshot wounds, being stabbed by lances and bayonets in the fury of action. Some striking examples of this fact occurred during the Crimean War. Private J. Boxall, of the 4th Light Dragoons, was pensioned out of the service in April 1856, for a badly united fracture of the left femur caused by a gunshot wound at the action of Balaclava. He fell from his horse, and in the fall severely injured his right knee. While on the ground he received no less than twelve lance wounds. Private S. Weale, 38th Regiment, received a perforating bullet-wound of the left hip, a shell wound of the hip and another of the head, and while on the ground received a large number of bayonet wounds, viz., twelve, in various parts of the body. The official history of the Crimean War mentions the case of an officer who recovered after being shot through the leg, and receiving seventeen bayonet stabs at the battle of Inkerman; and asserts that few men were bayonetted at that battle who had not already received a gunshot wound which had partially or entirely disabled them.[26]

Multiple wounds from shell fragments.—Shells, when they happen to burst in a group of men, or even near a single soldier when he is in the upright position, are particularly liable to inflict several severe wounds in the same individual. They not only cause injuries by their own fragments, but also by stones and other hard substances forced up at the moment of explosion. Many instances of soldiers receiving more than one wound or injury at a time occurred in the trenches before Sebastopol, from the men being more or less confined in position, and from the effects of secondary projectiles derived from the parapets or surrounding objects. A remarkable instance of severe multiple wounds, which I saw under the care of my friend the late Mr. Rooke, was the following:—A private of the 77th Regiment, wounded by shell explosion, had an extensive part of the wall of the abdomen in the right hypogastric region removed, with laceration of the peritoneum and exposure of the intestines: a comminuted fracture of the crest and wing of the ilium; compound fracture of the right femur, and a fracture of both bones of the forearm, opening the wrist joint, together with extensive laceration of the soft parts in the neighbourhood of the broken bones. He was standing erect at the time he was struck. The forearm was amputated the second

day after the injuries were received, and ultimately, after 133 days' treatment in the Crimea, this patient left for England.[27] Another terrible example of multiplicity of wounds in the Crimea was the following:—Lieutenant D., of the 3rd Buffs, was wounded on the 17th August, 1855, by the fragments of an exploded shell. He had compound fracture of the thigh bones on both sides, of both bones of the left leg, with great exposure and laceration of the muscular coverings, the right knee joint opened, and simple, though comminuted, fracture of the right humerus. He also was standing up when wounded. No other than expectant treatment was practicable with such numerous and grave injuries. They did not cause death, however, until seven weeks after they were inflicted.

Multiple amputations from multiple wounds.—The occurrence of multiple wounds, when two or more fractures of bones have resulted from them, are sometimes shown in the classified returns of campaigns under the head of double amputations. Dr. Chenu, in his history of the Crimean war, tabulates forty cases of double amputations in individual soldiers for fractures caused by various projectiles, the larger proportion being by burst shells and grape; and, in the English history, nine similar cases are tabulated between April 1855 and the end of the war. More than one bone may be fractured in the same limb, and fractures of bones in separate limbs may be caused by a single projectile. Although, under ordinary circumstances, the bone or bones of one division of a limb only are broken by the stroke of a projectile, it can readily be understood how a man having his forearm bent on his arm at the moment he is hit, may have all three bones of the upper extremity fractured at the same time by the same bullet; or how a bullet striking one thigh sideways with sufficient force and breaking the femur, may pass on and fracture the bone of the adjoining thigh almost at the same instant of time. Drs. Ashton and Spanton mention the case of an officer who was wounded at Sedan in 1870 through both arms and both legs, and had all four limbs amputated. He was riding, when a ball passed through one of his legs, through the horse, and then through the other leg. At the same time a second bullet passed through both his arms. The horse was killed.[28] Under the circumstances of such multiple fractures, it may often happen that the treatment, suitable for either fracture alone, is found to be no longer applicable for the two combined. Amputation may be necessary in some such cases where conservation might otherwise have been attempted with propriety; and operative interference, such as amputation, may be rendered impracticable without the risk of entailing immediate fatal results in others, where it might have been performed with reasonable hope of a good result, if either one of the multiple wounds had occurred alone.

More precise information regarding this complication desirable

in future wars.—The probable frequency of the occurrence of multiplicity of wounds, and the important influence exerted by it in increasing mortality in action: or, where immediately fatal effects are escaped from, its influence on the treatment that has to be adopted in particular cases, and on the effect of treatment; the additional shock to the system of the patients in all instances; the greatly increased and prolonged suffering entailed on them; together with the aggravated risks as regards the final results in many cases; these, and perhaps other, considerations make it desirable that more marked notice should be taken of this complication than it seems to have attracted hitherto—that not only the number of officers and men wounded, but also the number of the wounds inflicted on them, should be shown in future professional field returns, in case of the necessity for their use unhappily arising. The importance becomes greater in proportion as the destructive force of the projectiles employed, and the facilities for multiplying the number of projectiles discharged within short periods of time, are increased. There is good reason for believing that the preponderance in the number of wounds and injuries inflicted over that of the number of soldiers hit will be found to be much larger than it is at present known to be.

SECTION V.

AIDS TO THE DIAGNOSIS OF PARTICULAR FEATURES AND COMPLICATIONS OF GUNSHOT INJURIES.

The characteristic appearances of gunshot injuries, and the primary symptoms and complications with which they are usually attended, have been described in preceding sections of the work. In the present section it is proposed to point out some *extraneous* means by which a knowledge of certain facts connected with them, especially the presence or absence of foreign bodies lodging in them, may frequently be obtained, or the judgment respecting them assisted.

CHAPTER I.

AID TO DIAGNOSIS DERIVED FROM EXAMINATION OF THE COVERINGS OF WOUNDED PARTS OF THE BODY.

Information afforded by clothing.—The diagnosis in respect to certain circumstances connected with gunshot wounds may often be materially assisted by examination of the uniform, accoutrements, or underclothing of a soldier. The value of this examination is particularly shown in the determination of doubts regarding lodgement of portions of some of these articles; but questions as to the nearness or distance of a shot, the direction which a missile has had before entering, and, therefore, the direction it has probably taken after having penetrated the body, the probable site of its lodgement, if it should not have passed out, and other similar matters, may also be often helped towards a settlement by it. Nothing is more important, as regards diagnosis and prognosis, in any case of gunshot wound, than to be able to determine as exactly as possible the course a bullet has taken; and no means of observation, however slight, should be neglected which are capable of assisting a surgeon in acquiring this necessary information.

Arrest of projectiles by clothing without or with wounds.—After an action, the protection which has been afforded in particular instances by clothes or other articles carried by soldiers

always forms a subject of remark. Bullets are found in the folds of great-coats which have been worn across the shoulders or on the back, in knapsacks, in the padding of tunics, in the folds of handkerchiefs, and other such places.

These coverings and articles, however, are not always so situated, or from other causes, such as the amount of velocity of the projectile, do not always present sufficient resistance to arrest altogether the progress of bullets, though they may stop them sufficiently to prevent them from inflicting any but comparatively superficial wounds. So it occasionally happens that a bullet will have sufficient force to penetrate the body to a limited distance, at the same time carrying a portion of the wounded man's shirt before it, while, owing to the yielding nature of the material, it fails to tear a piece out of it. The bullet will then lie, as it were, at the bottom of a prolongation or pouch of the shirt, like the finger of a glove; and when the shirt is taken off the bullet will be brought away with it. The presence of the bullet will of course be observed, if due care be taken to look for it; but very often in the hurry of the moment it will slip away and escape without either the patient's or surgeon's knowledge. The shirt being untorn over the wounded part, however, will at once show that the bullet cannot have lodged in the man's body, even although the bullet may not be found. In the same way a bullet may strike a soldier's boot, and inflict a wound in the foot, without perforating the leather, or it may penetrate the leather, but fail to pass through the sock. In either case an inspection of these coverings will show that the bullet has not passed into the wound, and the forethought of making the examination may be the means of preventing an unnecessary exploration. Not unfrequently a bullet will pass through a boot on one side and through the foot, but be prevented by the leather of the boot from passing out on the other side. The missile will then be found in the boot if it be taken off with due caution.

Mr. Guthrie relates that he saw an officer just after he had been wounded at the battle of Vimiera, into whose wound the shirt had gone with the ball without any injury to the linen. On Mr. Guthrie 'pulling at the shirt, it came out from a depth of four inches a perfect cul-de-sac, having the ball at the bottom of it.' As the wound is described as 'having been received in the thigh,' it would be a portion of the free end of the shirt which had entered with the bullet, and this may explain its having been carried to so great a depth without being torn. Hennen refers to the wound of an officer who had several folds of a silk pocket-handkerchief carried into the pectoral muscles by a bullet. On withdrawing the silk from the wound the bullet came away imbedded in its folds. The unfettered condition of the folds of the handkerchief doubtless assisted in causing the occurrence. Dr.

Jobert saw a case in which a bullet, the force of which had been partly spent, failed to make a hole in the wounded man's shirt, but yet penetrated the cavity of the abdomen. On drawing the shirt out of the wound the bullet came too, and though a protrusion of intestine followed through the opening, it was reduced and the patient quickly recovered. In this case the accident of the shirt not being rent open prevented the lodgement of the bullet in the peritoneal cavity, and saved the patient's life.[1]

It is evident from the examples above quoted that it is not sufficient for a surgeon to examine only the uniform clothing worn by a patient. A bullet may perforate a soldier's great-coat, tunic, or some of his accoutrements, but yet not pass through the shirt; may pass through a trouser, and yet fail to make an opening in drawers, if they be worn under it. The garment that happens to have been next to the skin of the part wounded is that to which observation should be particularly directed.

Evidence afforded when projectiles have traversed coverings of the body.—But more frequently a bullet which has enough force to penetrate the body will have previously made an opening in the clothes or other articles covering the part of the body penetrated. A glance at the openings which have been thus made will often at once settle a question as to lodgement of some portions of the substances overlying the wounded part. A piece punched completely out of a leathern belt, the loss of a button, a hole in a coat, vest, or shirt, which the flaps or torn edges when replaced toward the centre fail to fill up, will indicate the probability, almost the certainty, of the absent portions lodging in the wound. It has already been mentioned that experience shows that modern bullets are apt, almost equally with those of former shapes, to carry such fragments before them on first entering wounds, and that they will then leave them behind in some part of their track, while they themselves either escape or remain lodged at some distance from the place of entrance. From the nature of such light substances, unless the fact of their presence has been previously ascertained by observation of the coverings worn over the wounded part, they will not improbably be overlooked at first by the surgeon, and only be discovered some time after suppuration has been progressing. No foreign body is so difficult to detect in the ordinary exploration of a wound as a piece of linen or woollen cloth.

It is a common occurrence when a fowling-piece has been discharged near to the body, to find a number of detached portions of the various articles comprising the clothing of the part wounded carried into the wound or wounds with the charge of shot. As their lodgement seriously aggravates the symptoms resulting from the wound, and as the danger to the patient is greatly increased so long as any of them remain, not only the fact of the removal of these substances from the clothes should be determined, but

the number of fragments, their size and extent, should also be as carefully established as is possible. By this means, on some pieces of cloth or linen being extracted, it will be known whether the whole or only part of the lodged foreign substances have been got away. The observation of the clothing thus not only assists diagnosis, but also becomes a help in respect to some of the details of treatment.

Evidence afforded by clothing as to distance of discharge of fire-arms.—The fact that a weapon has been fired close to a person is frequently more obviously apparent from the state of the clothes than it is from the appearance of the wounded part which was covered by them. If the clothes be woollen, they are not only more extensively torn than they would be by a shot fired from a distance, but they are blackened by the smoke and particles of gunpowder, much of which they retain in their texture. If the muzzle of the gun has been placed close enough for the flame of the ignited gunpowder to act upon them, they will also be scorched; and, if the material be cotton or linen, may even be set on fire.

Deputy Inspector-General Dr. Marshall has related the case of a malingerer in Ceylon, who wished to escape from further service in the army. He was brought to hospital with a severe wound in the leg. The soldier, who had been on sentry, declared he had been shot by an enemy from the adjoining jungle and that he had fired at him in return, but the marks of the gunpowder on the man's trouser near the wound showed that he had inflicted the injury himself. The state of the trouser proved that the musket must have been discharged, not toward the jungle, but close to his own leg.[2]

The greater the force with which a projectile is armed, or, in other words, as a general rule, the nearer the weapon is discharged, and the more obtuse the front of the projectile, the more complete will be the abstraction of a portion of the clothes against which the projectile strikes, and the greater the probability of its being carried into the wound. At the ordinary distances at which wounds by bullets are inflicted in warfare, the size, shape, and condition of the opening in clothes through which a bullet may happen to pass, will be found to vary according to the materials of which the clothes penetrated are composed, their texture, the shape of the bullet, its velocity, whether the cloth is detached and free, or whether it is in close apposition with some part of the body and tightly restrained from shifting its position, and again, in the latter case, whether this part of the body be soft and yielding, or hard and resisting.

Sizes and shapes of openings made by projectiles in clothing.—As a general rule, the size of the opening in articles of clothing covering a wounded part of the body should not be depended

upon for indicating with precision the size of the projectile which has entered. When a bullet happens to penetrate in a direct line, the diameter of the hole in the cloth or linen covering the wounded part is usually smaller than that of the projectile or than that of the wound itself, owing to the elasticity of such materials and also to the fact of the bullet being at its highest speed in reference to the wound, and being clear of other things which would help to widen its track. It is occasionally larger when part of the texture adjoining that which was immediately opposite to the bullet has been torn away with it. Neither, as a general rule, should the shape of the opening be regarded as showing the form of the projectile. A spherical bullet fired through broadcloth makes a round hole, but through an ordinary piece of canvas makes a square hole. This is owing to the different textural arrangements of the two substances. In the broadcloth the woollen fibres are closely mingled together, so as to form almost an uniformly even layer; in the coarse canvas the threads cross each other at right angles, and are readily disconnected. The crossing threads which remain entire in the canvas after the passage of a bullet, and which bound the portion carried away by it, necessarily form a square, while the fringed ends of the threads which have been stretched and then divided recede into the adjoining texture, especially after the canvas has been drawn open or put on the stretch. The opening made by a spherical bullet in a linen article of clothing on a wounded person, when a portion of its substance has been carried away, will sometimes present a rectangular appearance from the same reason, but at other times will be a torn hole of irregular outline, particularly if the texture be fine and close.

Openings of entrance and exit in clothing.—In any case, if a bullet make a wound of entrance and another of exit through a part of the body covered by clothes, especially woollen clothes, whether it be a member of the body or part of the trunk, a careful examination of the clothes covering the wounded part will scarcely ever fail to determine which has been the first, and which the second, opening. A round bullet, or any bullet of sufficiently obtuse frontage, passing through a part of the body so covered, punches out, as it were, the part of the cloth which it first strikes, and so makes a hole through which it enters; but, in escaping again, it ordinarily forces its way out by simply tearing the texture of the clothes asunder. Part of the cloth is carried away from the first opening, while, as to the second, the torn edges, on being brought together, close it; or, if they do not completely cover it, the part absent is very much less than that which has been abstracted at the first opening. The clothes will thus almost invariably give valuable evidence on a question being raised as to which has been the wound of entrance and which the wound of exit of a projectile, as well as afford information on the probability of

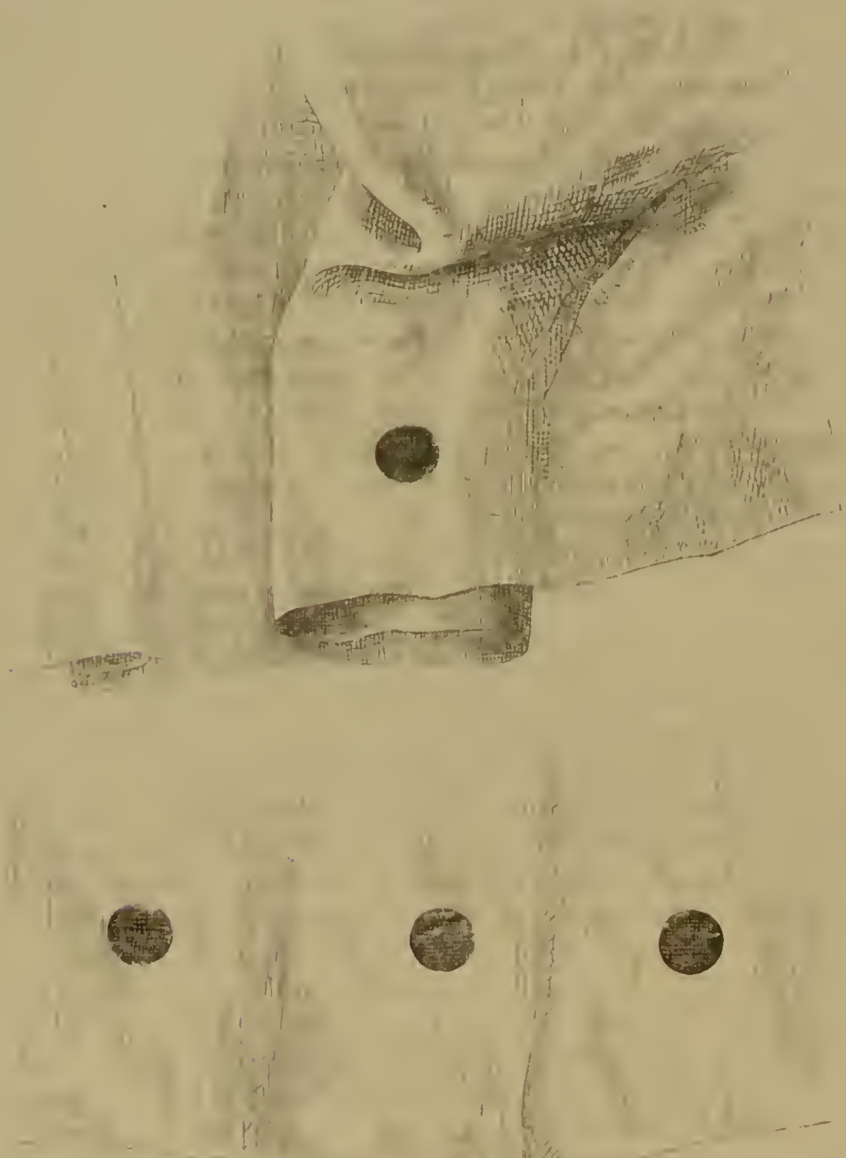
lodgement of pieces of the materials composing them; and as the relative conditions of the two holes in the clothing cannot of themselves change, clothes are capable of giving their evidence on these points for an indefinite time, which is not the case with the wounds themselves.

It follows from what has been said that evidence may be obtained from observing the condition of a wounded man's clothes, which will not only be valuable in clearing up doubtful matters of practical importance that often engage the attention of military surgeons, but some also that may be of great service in trials before criminal courts of law.

Evidence afforded by the number of openings made by projectiles in clothing.—Some few years ago I saw a case of gunshot wound which was under the charge of my friend Mr. Sampson, of Southampton, in which a careful examination of the patient's clothes settled several points which must, without this examination, have remained in a state of uncertainty. A man committed a murder, and afterwards tried to destroy himself with a revolver pistol. The question arose whether he had fired two bullets, or only one, against himself. On taking off his clothes a slightly flattened pistol ball dropped on the ground. An examination of the patient's chest showed only one wound, viz., a small valvular opening between the cartilages of the third and fourth ribs, about half an inch to the left of the sternum. The termination of this wound could not be reached, nor could any proof of the lodgement of a foreign body in it, or elsewhere, be obtained. But, in addition to the foregoing wound, there was a slight contusion beneath the left nipple which might, or might not, have been made by a bullet. One bullet only appeared to have passed through the man's cloth coat and waistcoat. There was an opening firstly through the thick lappet, and secondly through the breast of the coat, as well as through the corresponding part of his waistcoat; and the direction of these openings led slantingly to the situation of the bruise beneath the nipple. The ball, which dropped when the man was being undressed, on being examined under a magnifying glass of low power, was found to have some small fibres of cloth of a magenta colour pressed into its substance. Further examination showed that between the layers of cloth of the man's coat was some padding, part of which consisted of cloth of the same particular magenta colour, and also that this padding had been penetrated by the bullet. There could then be no longer any reasonable doubt that the bullet, which had passed through the man's coat and waistcoat, was the one which was picked up, and that it was by this bullet the contusion below the nipple had been inflicted. The man wore a flannel shirt, and beneath it a woollen under-vest. There was no hole through either of these near the bruised skin below the nipple. But above, nearly opposite to the spot at which

the wound was found in the chest wall, a hole was found in the flannel shirt, and two holes, alike in size and less than an inch apart, in the woollen vest beneath. The hole through the flannel shirt, at a part uncovered by coat or waistcoat, was easily understood: but whence came the *two* holes in the woollen vest? For

Fig. 27. (*a*)



Sketch showing three openings from a bullet passing through a fold in a garment.

some time the existence of the two holes in the vest was sufficiently puzzling. It was thought that if the part of the woollen vest implicated had been doubled upon itself while on the man's chest, the bullet must have passed through three layers and have made three openings. Experiment showed, however, that if the dupli-

cature were of such a character that the edge of the under-doubled part came exactly beneath the spot where the ball happened to enter in front, or *vice versâ*, then, under these circumstances, a portion of the united upper and under surface of the doubled edge beneath being carried away together, one hole in front and only

FIG. 27. (*b*)

Sketch showing how the bullet may make only two openings in the same garment

one hole behind would be the result. The perforated substance would consequently exhibit two holes near to each other on being opened and laid flat. This was the explanation, then, arrived at. The man had fired two bullets against himself; one, after having

traversed the thick folds of the padded cloth coat, had had its force so lessened as to be able only to effect a slight contusion; the other, passing through only the exposed flannel shirt and the under-vest, which had happened to be doubled in the manner described, had caused the open wound, and, having passed deeply, had lodged, whether at some spot in the chest wall or within the cavity of the chest, observation afforded no means of determining.

The illustrations, figs. 27 (*a*) and 27 (*b*), show at a glance how a single projectile penetrating a fold in the body of a shirt may leave behind it either two or three holes in the shirt, according to the part of the fold it has happened to pass through. It needs no illustration to show that if it be any part of the free border of a shirt or other garment doubled on itself, not a plait in the body of a garment, through which a bullet passes, either one or two holes only can result. Three holes could not be produced under such circumstances.

Evidence afforded by the hair covering parts of the body.—Analogous with the information which may be occasionally afforded by examination of the artifical coverings of the body in respect to the course a projectile has taken, or to a question of its lodgement, is that which may now and then be derived from the natural covering, the hair. The hair on the surface of the body, like fibres of wool and feathers under corresponding circumstances, is remarkably little acted upon, or altered in condition or appearance, by the force of a bullet even at full speed. If impinged upon by a bullet, these substances are usually carried forwards for a certain distance in front of it, and then being released owing to the rotation of the projectile, or being caught and drawn aside by some of the tissues forming the boundaries of its track, they are left somewhere behind in its wake.

A very striking instance of the practical account to which a recollection of this circumstance may be turned is the following. During the war of the rebellion in the United States a soldier was struck by a rifle-bullet in the left temple. On the fourth day after the wound he came under the care of Dr. B. Howard. The patient was able to give his surgeon a very complete account of the history of the injury. On examination by a probe the bullet was found to have travelled beneath the skin obliquely across the forehead, until it had passed a little beyond its most prominent central part. At this point, to the right of the median line, was a small incised wound in which the bullet track terminated. This incision, the patient explained, had been made by a passing surgeon on the field, and through it, he stated, the bullet had been extracted. Above this small cut a slight depression could be felt, through the skin, in the bone. The case was regarded, however, as a flesh wound, but precautionary treatment was adopted. All went on well for a few days, when symptoms of compression showed

themselves, and coma became almost complete. It was then determined to make an examination of the part where the depression in the bone could be felt. On exposing this spot the bone was found to be fractured, but the depression was moderate, and there was no opening through which a foreign body might be supposed to have entered the cranium. At one spot, however, in the line of fissure, the end of *a single hair* was seen to be protuding from within the broken bone. Reasoning upon this circumstance, the conclusion was arrived at that the hair could not have been driven into the skull by itself; it must have been carried in by the bullet which caused the fracture, or by some other solid foreign body. Some bone was then removed by trephining, and at a depth of about two inches from the surface a distorted minié bullet was discovered, and from this situation extracted. The patient eventually recovered, and subsequently resumed service as a cavalry soldier. Here all the evidence was opposed to the supposition of a bullet having penetrated the brain, with the exception of that afforded by this solitary hair. There was no visible hole in the skull, the tongue of bone which had been driven in by the bullet having sprung up again and closed the aperture; the patient's statement that the bullet had been removed by a passing surgeon was seemingly confirmed by the incision which had evidently been made by some one with a view to extract it; and it was not at all likely that a bullet entering near one of the temples, traversing the rounded forehead beneath the skin, and reaching its most prominent aspect, should then have fractured and penetrated the cranium. The situation of a single hair, however, decided that all this evidence was deceptive. It assured the surgeon that a solid foreign substance had entered the cranium, and led to the detection and removal of the bullet, which, had it remained lodged, must have caused all other attempts to save the patient's life to be fruitless.[3]

CHAPTER II.

AID TO DIAGNOSIS DERIVED FROM EXAMINATION OF PROJECTILES.

WHEN the projectiles by which wounds have been caused are not lost, a careful examination of them will occasionally afford evidence of diagnostic value in respect to the nature and complications of the wounds inflicted by them. The forms, composition, and other physical qualities of projectiles will also, not unfrequently, as may be readily imagined, convey important information when medico-legal inquiries are instituted regarding the circumstances of gunshot wounds occurring in civil life. It is always

well, therefore, for surgeons under whose care such cases happen to fall, both in military and civil practice, to take notice of the bullets, or portions of bullets, or other projectiles which have caused the wounds, whenever they have the opportunity of doing so, whether they may be extracted by surgical operation, or obtained by other means. In civil practice they should always be cautiously preserved, together with any other extraneous substances which may happen to be with them in the wounds, in case of questions being asked on matters which they may serve to elucidate.

Markings impressed upon bullets.—It is remarkable what delicate marks will occasionally be impressed on the surfaces of leaden bullets by even comparatively soft objects with which they have happened to be brought into collision, and how distinctly these marks will be retained, notwithstanding the bullets subsequently pass through parts of the body, provided only that they are not violently impelled against bone during their passage.

Sometimes a bullet in passing through clothes will take a perfect impression of their texture. Dr. Archer, of the 98th Regiment, gave me a small spherical bullet with a piece of hempen cloth, which I have deposited in the Museum of Military Surgery at Netley, and in this instance the impression of the particular texture of the cloth is as strongly marked on the bullet as if it had been purposely engraved upon it. The bullet was fired from a matchlock musket during the Umbeyla Campaign, and struck a native dresser on the outside of the thigh. It cut out a piece of his dhootie (an article of dress peculiar to men in India), carried it before it, and lodged beneath the skin on the inner aspect of the limb, whence Dr. Archer excised it. The cloth remained in close contact with the bullet at the time it was extracted, and as the projectile was very little altered in form, it had no doubt passed through the limb without having come into collision with the bone. The arrangement of the texture of the hempen cloth, which it first met on striking the limb, may be perfectly seen on the bullet.[1] The marks of the threads are flattened and widened in front where the pressure was most direct, and the meshes are enlarged towards the outer limits from the cloth having been stretched round the convexity of the bullet before the threads separated; but the general texture of the cloth is so well marked that there could be no difficulty in identifying it.

Substances imbedded in bullets.—Fibres of cloth, linen, and portions of hair, are constantly impacted in the substance of the lead of bullets. Some incrustation on a bullet removed from the thigh of a soldier at Netley, two years and a half after the date of the infliction of the wound, was submitted to microscopical examination. Abundance of cotton fibre was observed in it. Some of the fibres were of a blue colour, some were white. On enquiry

it was then ascertained that the bullet, before striking the patient, had struck and carried away a piece of the cotton rug covering the cot on which he was lying at the time he was wounded. The colour of the rug was blue and white in alternate stripes.

When a leaden bullet strikes a bone in such a way as not to break it, yet with sufficient force and in such a direction as to denude it of its periosteum, it is not only more or less flattened, but also acquires an impression of the irregular surface of the bone, the bullet being rasped by it as it were. These marks are generally well preserved, however circuitous its subsequent course through the soft tissues may be. Sometimes it breaks down some of the fine ridges or other projecting irregularities which mark the outer surface of the bone, and minute *débris* will then remain firmly imbedded in the projectile. Such evidence, when it can be obtained, as it may be in case of the bullet lodging and being extracted by the surgeon, is always of diagnostic interest. The injury may be one that will shortly be repaired if the bone has not been struck; while, if struck, the case will be probably a protracted one, owing to the contusion to which the bone has been subjected, and its probable consequences—exfoliation, perhaps medullary inflammation, and other results according to the constitution and state of health of the patient. In the one case the injury may be a slight one, in the other of a serious nature; and the evidence afforded by examination of the bullet may in each case be the only certain clue to its nature to be obtained by the surgeon in the early period of the treatment.

The following incident will show that an observation of this nature may be of importance in influencing the steps of a surgical proceeding. My experienced friend Sir Anthony Home, who tried, during the war in New Zealand, Dr. Chisholm's plan of treatment for rapidly healing gunshot wounds, wrote to me from Wanganui, in June 1865, an account of the results of his practice in this particular. Among other points he mentioned the following: 'On another occasion, when the case seemed just the one for another trial, I had the scalpel in my hand, and had all but commenced the incision when some one brought me the bullet just then found. On examining it I saw that it was scored by having been in contact with bone, and consequently that the case was one in which the procedure was inapplicable. I had examined the track of the ball through the calf of the leg most carefully throughout, and was satisfied that the bone had not been touched. The scored ball gave the truest information.'

When a bone struck by a bullet has been completely fractured, or only a splinter has been broken off, the projectile almost always retains some particles of the bone in its substance. The fragments are usually very small in size, though one or two are generally sufficiently distinct to be perfectly recognisable by the eye without

a magnifying lens. Many examples of this fact may be seen in the Museum at Netley. Occasionally such fragments are sufficiently large and projecting to increase the injury done to other structures by the bullet in its passage. A bullet after having fractured a rib has been known to widen the area of laceration of a lung which it has subsequently traversed owing to a fragment of bone of considerable size having become fixed in its substance. Ordinarily, however, the pieces of bone imbedded in bullets are of the usual size of particles of sand or small gravel. Particles of bone imbedded in this way may occasionally give evidence of the injury which has been inflicted, which may not be obtainable by any other means. I had a soldier under my care in the Crimea who was shot in the loin. The bullet lodged, and all trace of it was left. I took the precaution of arranging for the dejections to be isolated, and the bullet was subsequently recovered, being voided per rectum. It was a conoidal bullet, the apex had been turned back, and in it were impacted some minute particles of bone. This could only be from the bullet having come into collision with some part of the spine, but there was no paralysis, nor any other obvious symptoms of injury to the spinal cord. Three years after the date of the wound this patient died in Guy's Hospital. At the post-mortem examination it was seen that the bullet, after passing through the spinal muscles on the right side, had entered the spinal column through the space between the third and fourth lumbar vertebræ, breaking the laminæ, had crossed upwards and towards the left side, and had finally left the canal between the second and third vertebræ. It had entered below the termination of the spinal cord, and had taken its course outside the membranes of the cord.[5]

Bullets that strike hard substances before entering the body will frequently retain particles of the objects with which they have been brought into collision, and these occurrences may occasionally be turned to diagnostic account. An officer, who was for some time under my observation, had received a severe and extensive wound near the knee-joint from a rifle bullet, while struggling with a wounded bear in India. Numerous fragments of the bullet were extracted during the progress of the case. It was not understood how the bullet could have struck with force enough to be so completely broken up, and yet only the surface of one of the condyles of the femur have been injured by the missile, until a piece of silex was observed to be imbedded in one of the lead fragments. It was then obvious that the bullet had not hit the bone with direct force, but had first struck the ground close to the part where the limb was wounded. The bullet had been broken into fragments, and it was these fragments which had penetrated and inflicted the injury.

Thus circumstances connected with gunshot wounds may be frequently ascertained, many years after their occurrence, by close

examination of leaden bullets under a magnifying lens of fair power, owing to the facility with which particles of objects struck by them become imbedded and fixed in their substance, and the length of time they remain there unchanged. It is seldom, indeed, that the fact of a leaden bullet having struck bone, wood, sand, glass, woollen cloth, hair, cotton, or linen, may not be proved, years afterwards, by minute examination of the projectile. The mixed lead and tin projectiles are not so hardened as to prevent them from being likely to afford similar evidence occasionally under corresponding circumstances, but they cannot be expected to do so with the same certainty as bullets made of pure lead.

Evidence afforded by weight.—The weights of the rifle and pistol bullets used by the armies of civilised nations are mostly of fixed standards, and can generally be ascertained without much difficulty. This knowledge may also be occasionally turned to use in practice. It has already been mentioned that leaden bullets, after entering the body, frequently have a layer shaved off or small pieces broken from them. By weighing an escaped or extracted bullet, it can be determined whether any portion of its substance has been removed. Should a deficiency in weight be detected, it may be suspected that a fragment is left behind, and this will naturally be watched for during the subsequent dressings of the wound. On this hint alone a detached fragment will sometimes be looked for and found; whereas without it its lodgement may remain unsuspected, and all the ill consequences, elsewhere noted, of the lodgement of a rough and angular fragment result. A scale of lead from a bullet may produce irritation and pain for years, until it is removed, may give rise to secondary hæmorrhage, and, as in a case elsewhere mentioned, may cause amputation to be resorted to, or may occasion other untoward results. For these reasons it is always a source of satisfaction after the extraction of a distorted bullet, or of one or more fragments of a divided bullet, to ascertain that the full amount of weight of lead has been obtained.

When a deficiency in the weight of an extracted projectile is noted, it need hardly be said that before taking any active measures to search after the missing portion, the surgeon should satisfy himself that the whole bullet had originally entered the wound. The history and circumstances of a case on being sifted will generally afford sufficient indications on this point. A soldier was admitted into Fort Pitt Hospital, who had been wounded some weeks before by a bullet from an Enfield rifle while at target practice. The bullet had lodged at the time of the accident, and had not been removed before admission. It had entered the right cheek, and had passed downwards, fracturing the lower jaw in its passage. On examination of the patient a foreign body was detected as it lay imbedded in some swollen soft tissues below the

maxilla. From this spot two flattened fragments of the bullet were removed in succession, and no more could be discovered. The two fragments were found to weigh only 280 grains, while the bullet, if complete, would have weighed 530 grains. The first opinion formed, therefore, was that the remainder of the lead was still lodged, but it was easily ascertained on inquiry that only a part of the bullet had entered the wound. The original bullet, before striking the patient under examination, had previously passed through the face of another soldier, whose jaw it had also fractured. It was ascertained that the bullet had been broken when brought into contact with the maxillary bone of the first soldier, for part of it had been deflected, and had lodged in the nape of his neck, whence it had been excised. The rest of it had passed on, and had lodged in the face of the second soldier. Had no care been taken to obtain this history, further search would probably have been made for the purpose of trying to discover the missing portion; as it was, no further search was made and the wound healed completely, thus confirming the correctness of the conclusion which had been arrived at, that no more lead was lodging in it. Such want of forethought does sometimes occur. Medical officers are familiar with the story of a surgeon who, after long exploration of a gunshot wound, and much torture of his patient, happening to remark that he must give up further search for the bullet, was addressed with much bitterness by the wounded man in the following terms:—'Is that what you have been doing all this time? why didn't you ask me about it? I have got the bullet in my pocket.'

SECTION VI.

SECONDARY COMPLICATIONS OF GUNSHOT INJURIES.

General remarks.—An account of certain secondary complications to which gunshot injuries are liable is given in the present section. These accidents, which may or may not supervene on gunshot injuries according to variations in the circumstances attending them, are very diversified in kind and in degree. They are derived from widely different causes, and the modes in which they are manifested are equally dissimilar. They may in some instances be due to certain phases of the original injuries, such as their nature and extent, or primary complications; in others, to peculiarities of individual constitution or previous habits of life; but, more generally, are attributable to special external conditions to which the patients have been subjected subsequently to the receipt of their injuries.

The secondary complications of gunshot injuries may be conveniently divided into two categories—local and general. In the first category the complication is not only local in origin, but remains local, and the constitution of the patient, if disturbed at all by it, is only secondarily so; in the second, although the exciting cause may have been local in its origin, the affection is chiefly a constitutional one, and when local appearances are presented they are manifestations of the general disease of which the patient is the subject, and not simply indications of mischief confined to the particular locality in which they are seen. In the first category may be classed: inordinate inflammation at the seat of injury; gangrene; secondary hæmorrhage; and development of maggots. In the second category may be placed—hospital gangrene; pyæmia; tetanus; erysipelas; and traumatic delirium.

CHAPTER I.

INORDINATE INFLAMMATION AFTER GUNSHOT WOUNDS.

Normal inflammatory action after gunshot wounds.—Every gunshot wound, the most trivial as well as the most severe and com-

plicated, is naturally followed by inflammatory action. There is swelling, heat, tenderness on pressure, increased sensitiveness, aching pain, a sense of stiffness and objection to movement in the part wounded. With these local symptoms there is also general febrile disturbance. The time when these signs of inflammatory action manifest themselves will vary in different instances. They may appear in the course of five or six hours after the infliction of the wound, but generally within the first twenty-four hours. The greater the momentum of the projectile, and the more profound the impression made on the parts with which it has been brought into collision, the less early does the local excitement usually appear; just as happens with regard to general pyrexial disturbance in relation to the amount of systemic shock by which the infliction of the wound may have been attended. In trifling wounds the local inflammation is very limited, and no fever will be noticeable; and in most gunshot wounds of a simple uncomplicated description, when they occur in healthy subjects, the local inflammatory action and general fever are only moderate in degree. They usually subside in the course of a few days, particularly at the time that suppuration is established, and the sloughs, which have been acting as irritants to the parts adjoining, are undergoing the process of removal.

Excessive inflammation and its usual causes among soldiers.—In other gunshot wounds this favourable reparative process is impeded at the outset by excessive inflammatory action. In some instances there is no obvious cause to explain the abnormal excitement, while in others the origin of the disturbance is plainly apparent. Certain organs, such as joints, when they are subjected to injury by projectiles, have a natural special tendency to excessive inflammation. In other instances, as in wounds of the soft parts where no special organs are concerned, the inflammation may be of the moderate kind before-mentioned, or it may be inordinate in degree. Excessive inflammation in such wounds is especially met with in soldiers who have been exposed to lengthened transport in springless vehicles over bad roads, whose wounds, therefore, have been subjected to frequent jolts and prolonged agitation; in sinuous wounds beneath fasciæ; in wounds complicated with the lodgement of angular fragments, pieces of cloth, and other foreign bodies, or that have been irritated by inconsiderate explorations in search of them; in cases where the wounded patients have been exposed to neglect, to extremes of temperature, to inclement weather, or where they have indulged to excess in alcoholic stimulants before reaching a hospital; or where they are placed under the influence of unhygienic conditions after arrival in one. Under the circumstances above-mentioned all the characters of the inflammation—the heat, swelling, vascular excitement, and sensibility—are liable to become so exaggerated that the process

of repair is arrested. The fever accompanying the traumatism is proportionately aggravated in degree and prolonged in duration.

In particular cases in which the inflammation, though inordinate in degree for a time, becomes controlled, and the patient regains a normal or nearly normal temperature and pulse, but an accession of local inflammation and general fever then occurs, some fresh exciting cause must be looked for. It may be something connected with the wound itself, as confined pus or sloughs, the movement of foreign bodies exciting additional irritation, or it may be a sign of the onset of some more serious change—of approaching erysipelas, extended cellulitis, or some form of septic poisoning.

Inordinate inflammation with constitutional depression.—Again, inordinate inflammatory action may be met with in gunshot wounds, yet its features be essentially different from those just described. The inflammation before-mentioned generally occurs early in the case, and is itself of an active character. But gunshot wounds are liable to be complicated with inflammation, which may be rather said to be passive in its nature. This form of inflammation is usually met with at a later period in their progress. It will occur occasionally at an early period, when the wounds have been attended with much loss of blood, when they have happened to soldiers who have been much reduced by over-fatigue, loss of rest at night, bad diet, prolonged exposure to wet and cold, and who, in consequence, have sunk into a generally anæmic or scorbutic condition; but, for the most part, it is met with in patients who have been for some time under treatment in hospital. The constitution of the patient has become depressed, and under the lessened power of resistance that results from this condition, the inflammatory excitement previously existing assumes a more marked character, or becomes aggravated by some comparatively slender source of irritation. The local signs of inflammation are all present, but they do not exhibit the same amount of active energy as the early inflammation did, which was induced by the causes previously noted. The accompanying constitutional disturbance partakes equally of a depressed character. With each of these complications the process of repair in the wound is impeded or altogether stopped; but in the one instance the arrest is due to inordinate action associated with constitutional vigour, in the other case to inordinate action joined to a deficiency of constitutional vigour. A proper estimate of the differences in the nature of these two forms of inflammation becomes of great importance when the question of treatment has to be considered.

Consequences of inordinate inflammation.—Inordinate inflammation, unless checked, entails consequences of different degrees of gravity. In the severest degree it leads to strangulation,

defective nutrition, and loss of vitality, in parts which were more or less indirectly damaged by the projectile, though not directly struck by it. In a less severe degree it may induce excessive suppuration, the matter being collected deeply or being diffused, while the parts for some distance around the neighbourhood of the wound are left in a brawny unyielding condition from infiltration with lymph. In all cases, as before mentioned, it interferes with, or completely arrests, the natural processes of repair while it lasts.

CHAPTER II.

GANGRENE AFTER GUNSHOT WOUNDS.

Gangrene as a normal sequence to gunshot wounds.—When a part of the body is penetrated or scored by a projectile armed with sufficient force, one effect of the violence, as already mentioned elsewhere, is to cause a cessation of vitality in a portion of the organised structures immediately subjected to it. The mortification which ensues, extends to a greater or less depth according to circumstances, inflammation takes place in the surrounding structures, a process follows by which the mortified part is cast away, and a healing action succeeds. The death of tissue in such a case is limited to the direct sphere of the violence, and the dead substance is thrown off as a slough.

This is what takes place in most gunshot wounds of a simple kind under favourable conditions. The sloughing is a primary and essential feature of the wound itself: it cannot be regarded as a complication of it.

Superadded gangrene—local and distant.—But under other circumstances the mortification is not thus limited. An unhealthy action may spread from the sphere of violence to parts beyond, and this secondary action may lead to the death of the parts involved in it. When this destructive process takes place, it is truly a complication of the original injury, whatever may be the extent of its occurrence. Again, the nature of the wound may be such that, in consequence of injury done to some particular structures concerned in it, the resulting interference with their functions, or the complete arrest of them, may lead to loss of vitality in other structures at a distance from the seat of violence itself. Thus such general mischief may be done to the upper part of a limb by a massive projectile, or such damage to the principal vascular trunks by a projectile of small size, that mortification may commence at the ultimate part of the limb, and progressively extend upwards, until a great portion of the parts below the site of the original injury may be brought into a condition of sphacelus. This

progressive destruction, indirectly induced by the action of the projectile, whether extending from the wound itself or commencing at a part remote from it, is what is understood by the complication of *Gangrene* in gunshot wounds. It is sometimes designated *Traumatic Gangrene*, but the expression hardly serves to particularise the complication under notice. The tissues which are primarily deprived of their vitality by the direct impact of the projectile, no less owe their death to the traumatism to which they have been subjected, than the sphacelated parts which have been deprived of their vitality through its indirect effects.

Gangrene, as a complication of gunshot injuries, is met with then under two forms, and these may be distinguished, in respect to the wound which has been their primary cause, as '*Local Gangrene*' and '*Distant Gangrene*.' The causes of the two kinds are distinct, and so is usually the nature of the treatment which they severally require.

Local gangrene.—The causes of gangrene which spreads locally from the seat of a gunshot injury may be either local themselves, or they may be constitutional, or, what most frequently happens, both the local and the constitutional causes may be combined.

Local gangrene as a result of excessive indirect injury.—Locally induced gangrene is most frequently met with in lacerations from heavy fragments of shell, injuries from grape-shot, and other projectiles of similarly large size and weight. Beyond the limits of the tissues which are completely disorganised and killed outright by the momentum of these heavy shot, there are other tissues, to which so much structural damage has been done by the pressure, extreme stretching, or violent agitation to which they have been subjected, and whose condition is additionally so much deteriorated by the presence of a quantity of effused blood in the interstices of their fibres, that they are deprived of the power of resuming their normal functions. They become more and more cold, whatever sensibility is left in the injured parts becomes lessened, and at length vitality entirely ceases. There is no line of demarcation between the parts which have been utterly destroyed in the first instance and the adjoining parts which, though they have not been injured at once to this last degree, have nevertheless been wounded so excessively as to be mortally damaged. What follows will vary, so far as the local cause is concerned, according to the size, weight, and force of the projectile, and the distance and depth to which the sloughing action extends. If these be within certain moderate limits, all may go well, repair taking place in the same way as when there is only a mere superficial slough; but if they be so extensive as to materially interfere with the integrity of the limb in which the injury has happened to be inflicted, or as to occupy so much bodily space as to induce grave constitutional depression, then the process of mortification may, without any

evidence of local inflammatory action, though not without increased constitutional disturbance, go on spreading and invading structures which could hardly have been affected by the original injury, until the patient at last sinks under its effects. There is not sufficiency of local power on the part of the living tissues to establish a barrier between themselves and those which have been destroyed by the original injury, and they succumb to the deleterious influence of the mortified parts in their immediate vicinity.

Gangrene as a result of inordinate inflammation.—On other occasions inordinate inflammation, that is, inflammation in excess of the strength of the tissues involved in it, appears to cause the occurrence of gangrene. The usual signs of inflammatory action, which are presented up to a certain point, disappear from the parts immediately around the wound; and, in their stead, those of commencing mortification take their place. The comparatively sudden change from heat, pain, and redness in the parts, to coldness, insensibility, and loss of circulation, in the absence of any other explanatory cause, seems to leave no doubt that the relatively excessive inflammation has itself been the cause of its own cessation.

Extent of wounded surface.—The depth and breadth to which the parts are injured by a gunshot projectile of large size may induce the spread of gangrene by interfering with the supply of blood and nervous energy to the adjoining structures. Thus, if a mass of shell crush a part of an extremity, so that bone is broken and nearly the whole circumference of the limb is involved in the injury, gangrene surely extends along the distal parts, if the limb be left to itself, because the sanguineous and nervous currents which are necessary for the preservation of their vitality are arrested. But the large extent of surface injured certainly influences in some cases the fact of a wound being followed by spreading gangrene instead of by healthy action, independently of any arrest of the supply of blood to the parts which become gangrenous. I have before referred to the case of an officer in the Crimea who was wounded at the same time by two grape-shot. The wounds were simple flesh wounds, without injury to any vital organ or vessels of large size. Both shot had, however, severely crushed the opposing tissues, and had penetrated deeply; one lodging in the muscles of the back, the other passing from the back into the inner aspect of the upper arm, but without injury to the axillary vessels or nerves. The superficial sloughs were not eliminated, but gangrene slowly went on spreading along the areolar tissue and neighbouring structures, accompanied by great nervous irritability and constitutional disturbance, until the patient died. There was no attempt to form a line of demarcation between the dead and the adjoining tissues. In this case the extent of injury seemed to be the chief cause of the gangrenous degeneration, for the patient's constitution was to all appearance in a good state at the time his injuries were inflicted,

though the duration of his service in the Crimea, which had been considerable, may have caused this appearance of bodily strength to have been somewhat deceptive. The hygienic circumstances under which he was placed after the injury were of the most favourable kind. This was sufficiently proved by the satisfactory progress made by two other patients with almost desperate wounds, who occupied the same hospital hut with him.

Recurrent gangrene.—In the majority of wounds in which gangrene occurs the disease will not proceed to the fatal extreme just mentioned. Either the gangrene, when suitably situated, will be arrested by local treatment, or the parts involved in it will be removed by operative interference, or it will cease from natural arrest of the unhealthy action. But in these comparatively favourable cases, after an apparently vigorous healing action has been established, the sloughing may recur, without any cause for suspecting a contagious or infectious origin as in hospital gangrene. There were numerous cases in which such recurrent gangrene occurred during the Crimean War. As they were generally accompanied with more or less indications of constitutional disturbance on the occasions of the recurrence, the inference was that they were chiefly attributable to general systemic derangement rather than to any external influence.

Spreading gangrene in wounded soldiers on active service.—Among the causes which determine whether an injury by a massive projectile is followed by an eliminating and saving inflammatory process, or whether it becomes complicated with spreading gangrene, it is obvious that the state of the patient's constitution at the time the injury was received must always act an important part. If the constitution be depressed from any cause, according to the degree of that depression will be the lack of power in those parts that have been indirectly injured by the projectile, and their inability to sustain the strain they must undergo during inflammatory action, so as successfully to detach themselves from the parts directly destroyed by the projectile. An energetic action is required to separate and throw off the mortified parts, but the previous state of the bodily structures concerned and the superadded injury prevent it. Among soldiers in time of war the causes of lessened constitutional vigour are very numerous. Their effects are often not manifest enough to be recognised by unprofessional observers, but they make themselves very apparent when they are subjected to the test of injury or illness. A scorbutic taint and chronic bowel derangement induced by bad diet, depression of vital force and pyrexial disturbance from loss of rest at night, from excessive and harassing fatigues, and from exposure to inclement weather of all kinds, are common circumstances in campaigning. When to these are added loss of blood from a wound, confinement in hospital, and that nervous depression so constantly observed

with sloughing wounds of much extent, it is evident that any unhealthy local action of low type may readily occur.

Gangrene from cold in the Crimea.—The effect of constitutional depression in creating a tendency to gangrene was witnessed to a large extent during the first winter in the Crimea in the so-called cases of 'frost-bite.' They had no analogy in character, appearance, or mode of progress with the cases of mortification produced by the effects of intense cold in northern regions on healthy subjects. Having been familiar with the appearances of frost-bite in North America prior to the time of the Crimean War, I was able to recognise the marked differences which the Crimean cases of frost-bite presented. The mortification during the winter did not take place in the exposed parts of the face, the ears, the nose, and other parts, as so frequently happens under low temperatures in cold climates; nor were those other cases met with, in which, when parts of the body or extremities have been partially frozen, mortification is induced by an imprudently hasty application of warmth to the frozen parts. In the Crimea nearly all the cases began in the extremities—in the toes and feet of men in whom excessive bodily fatigue, bad and insufficient nutriment, loss of rest, protracted exposure to damp without the means of procuring a change of clothes or ordinary warmth, and diarrhœa, had induced a condition of extreme anæmia and physical debility. The circulating fluid of the body was not only deficient in all the qualities of healthy blood, but the arterial system had hardly sufficient propelling force to distribute this fluid, such as it was, to the extremities. There was probably not an officer or a man, who was engaged in the siege operations at the front before Sebastopol throughout the early months of the winter of 1854–55, but had acquired a scorbutic condition of constitution to a greater or less extent. No wonder then that in numerous instances when boots, sodden with damp from the muddy trenches and kept on day and night, or frozen from marching through the snow, were cut off the numbed and swollen feet, it was found that mortification had already commenced. Cold, doubtless, was one ingredient in the production of the gangrene, but it was a very trifling one compared with others; indeed, in a very large proportion of cases the so-called 'frost-bite' took place when the temperature was considerably above the freezing point. During the second winter—the winter of 1855–56—the circumstances were all different. Some true cases of gangrene from exposure to cold then occurred, but they were few in number compared with those of the first winter, notwithstanding a large increase in the number of troops on duty, while the deaths which amounted in the first winter to 457 from this cause, in the second only reached six in number.[1]

Rapidly diffused gangrene after gunshot wounds.—In the kinds of local traumatic gangrene which have been hitherto noticed the

morbid action extends gradually, either marching on regularly day by day, or advancing with occasional halts. Sometimes, however, after a severe gunshot wound, the gangrene will spread with such fatal rapidity, that it appears to invade all the adjoining parts nearly at the same time. If instead of occurring in individual instances, and in some degree to be accounted for by the extent and gravity of the original wound, by the shock which has attended it, and perhaps also by the low degree of vital energy in the patient's constitution, it were only one among a large number of similar cases in which wounds of all degrees of gravity, and patients of all states of constitution, were attacked alike, the gangrene would hardly be distinguishable from true 'Hospital Gangrene.' It is not, however, accompanied with the intense burning pain which is a characteristic symptom of Hospital Gangrene, nor is there any ground for attributing to it a contagious character. It has chiefly been observed after injuries of the lower extremities from some of the larger forms of projectiles, especially when not only the soft parts but bone has suffered, and amputation has not been practised in the hope of obtaining a cure by conservative treatment. The features of the attack are very strongly marked. The wound suddenly becomes greenish and dark in colour, softens down, and emits a most offensive odour. The whole limb at the same time becomes swollen and œdematous; in parts, perhaps, is of an almost cartilaginous hardness; the skin loses its normal pinkness, and presents a dull white colour like tallow, then assumes a mottled appearance, and not unfrequently becomes studded with bullæ. The areolar tissue, along which the gangrene seems to have a special tendency to spread, becomes disintegrated and converted into a substance of semi-purulent pulpy consistence. This rapid extension of gangrene is necessarily attended by great systemic excitement with prostration, and speedily leads to a fatal issue. Examination of the limb after death shows not only the cellular tissue broken down and putrid, but the muscles softened and changed in colour, and, in fact, a gangrenous condition, more or less advanced, of all the structures. The attack, in all such cases, is probably preceded by some form of blood-poisoning, produced by absorption of morbid material from the wound itself; neither simple depression of vital force nor shock, alone suffice to explain it.

Suddenly developed local and general gangrene.—In some instances in the Crimea, gunshot wounds, but more particularly amputations consequent on them, were followed by a form of gangrene of even a still more formidable character than that which has just been described. No cases of the kind had been previously recorded. Dr. Lyons, in his report on the Pathology of the Diseases of the Army in the East, has described it under the designation of *True Local and General Gangrene*.[2] According

to the Official Surgical History of the War, it was only supposed to have occurred in one hospital in the Crimea, the general hospital in the camp,[3] where it attacked certain patients who had suffered specially severe injuries. But Dr. Lyons also met with it in other situations. The first case was noticed during the month of June, in a patient who had undergone amputation of the thigh for gunshot injury. 'Attention was first attracted by the peculiar shrunken collapsed state of the features, so familiar in the algid stage of cholera, and the coincidence was remarked that cholera prevailed with peculiar severity at the time in the camps of the regiments surrounding the hospital, and especially in the two nearest, viz., those of the 39th and 14th Regiments, from which most of the orderlies of the hospital were furnished.' In the description of the symptoms in the official history, many of the appearances characteristic of an attack of cholera are described as having been present, such as collapse, sunken eyes, thirst, lividity of face, and coldness and clamminess of surface, but the attack was not preceded by vomiting or diarrhœa, neither were cramps observed. The state of the urinary secretion is not noted.

Dr. Lyons states, 'The disease commonly appeared about the fourth, fifth, or sixth day. It was generally preceded by pain, more or less severe in the stump; there were also symptoms of general constitutional disturbance, sometimes violent, tumultuous, of sudden occurrence, and not easily explicable; but these were not constant, and, in some of the very worst cases, there was little to indicate the danger of the patient, and he was himself the last to suspect it. In several instances the morbid state, fully developed, though previously unsuspected, was first indicated by a peculiar intense odour emanating from the parts, and sensible at some considerable distance, and which, though difficult to be described, could never be mistaken after it had been once recognised. To those familiarised with it, this odour was perceptible upon entering the ward where the patient lay. On examining a stump thus affected, the flaps were found discoloured and gaping; the whole limb was immensely distended and in parts distinctly emphysematous; vesications filled with discoloured serum were not unfrequently found near the borders of the flaps; fœtid gas and a sanious dark-coloured fluid bubbled out from the wound; the areolar and adipose tissues, discoloured and apparently dead, protruded between the sutures where any of them remained. The upper parts of the limb were white and tallowy in appearance, and sometimes marked with a network of purple-coloured veins. The parts were insensible throughout, and the temperature was considerably diminished. The action of the heart was feeble, and the pulse excessively rapid, but weak. Death invariably supervened within a very short period; its occurrence was seldom protracted

beyond twenty-four hours from the time at which the state was first discovered.' The description of Dr. Lyons agrees in all essential particulars with that in the official history of the war. In the latter it is added that the removal of the dressings and sutures from a stump attacked by this form of gangere, was followed by the escape of a considerable quantity of fœtid gas, as if by explosion, attended with some relief of the pain and sense of constriction; and that, what appeared remarkable, notwithstanding the decomposition of the tissues, ligatures on vessels in all the cases held firmly. Neither local nor constitutional remedies had any effect in arresting the progress of the gangrene. The official history states that no case appeared to have occurred after July the 14th; but, in the cases cited by Dr. Lyons, there is one which he describes as the most rapidly fatal case which he had seen, and this took place in a young soldier who received a gunshot fracture of the right leg, on September the 8th, for which amputation was performed the same day.

The appearances presented on examination after death are described in full detail in Dr. Lyons' report, but are too long to be quoted. The following concluding remarks of the report contain all the most important particulars regarding them, as well as the views which Dr. Lyons was led to entertain regarding their immediate origin: 'Death of the parts more immediately concerned in the operation, gaseous distension of the limb, and more or less general emphysema of other parts of the body, almost total disappearance of the blood, and its replacement in the heart and vessels by gas, with more or less advanced decomposition in the viscera, have been the chief appearances found after death. The disease, as far as we know, has not a recognised connection with any particular age or type of constitution. We have seen it in the lad of eighteen, of light and active frame, and we have also met with it in the robust, stalwart, and perhaps too plethoric artilleryman. It has shown no tendency that we could ascertain to spread by infection or contagion. But on the occasions of June the 8th and 18th, the final assault on the Great Redan on September the 8th, and after the fatal explosion in the Right Siege Train on November the 15th, and in rare instances in the intervals between these periods, well-marked examples of it have been presented. There seems no way of accounting for these very remarkable phenomena, except by the supposition that they are the result of a sudden and general decomposition. The immediate origin of this decomposition may, not without some probability, be referred to a local, suddenly developed, but intense gangrene of the parts at the seat of injury or operation, which by a sort of pathological catalysis from the effects of the local organic decomposition, determines in the first instance a decomposition of the blood, and, through this medium, that of all the tissues with which it comes in contact. It

is remarkable that the various tissues and organs did not present the appearance of being merely dead, and spontaneously undergoing decomposition as in ordinary cases, but they seemed to show, in the changes so rapidly and intensely produced, the effects of a peculiarly destructive agency. The explanation of this agency is probably to be sought in the sudden and as it were explosive decomposition of the circulating fluid, its chemical constituents assuming the gaseous form in a sudden and violent manner, and the resulting gases in their expansion causing a mechanical separation and disintegration of the particles of the tissues.' No case of this formidable description of gangrene, which from the simultaneous occurrence of the local and general changes might have been almost called 'Concurrent local and general gangrene,' came under my own observation during the war; and I have therefore thought right to quote at some length the observations upon it of Dr. Lyons, as his position of Pathologist with the Army in the East, gave him special opportunities of observing it.

Distant gangrene.—Distant gangrene, when it follows gunshot injuries, is usually the result of some damage done to the principal vessels at the upper part of a limb, so that the supply of arterial blood to the distant parts, and generally the return of the venous blood from them, have been suddenly impeded. This may be the effect of a crushing injury by a large projectile in which the principal vessels are equally with other structures functionally destroyed; of contusion by smaller projectiles leading to obstruction both of the artery and vein; of contusion of the artery leading to constriction, though not to complete closure of its calibre, together with contusion and blocking up of the principal vein; of a wound of a vessel by a spicula of fractured bone, with extravasation and pressure as a consequence; or of direct division of the principal artery of the limb by the projectile. Any cause which may lead to an arrest of the general circulation in a limb which has been subjected to gunshot injury may equally entail gangrene as a consequence. If a patient, shortly after a wound near the principal vessels of the thigh, complain of coldness and numbness in the foot, heaviness of the limb, pain in parts; and if, further, the skin should assume the peculiar colour and appearance which Mr. Guthrie has graphically described as those of a tallow-candle passing into the aspect of mottled soap, even though no important bleeding may have occurred at the time of the injury or subsequently to it, a lesion of the vessels sufficient to cause gangrene may at once be suspected. All doubt on the subject is removed if, on placing the finger over the vessel near the wound, the pulsation, which is felt in the artery above, ceases to be perceptible below the seat of injury. Under such circumstances, if left to itself, the gangrene will gradually ascend, until at last a line of demarcation becomes established and natural amputation is effected; or, what is the more

probable issue, the gangrene rapidly extending, will assume such proportions that the patient dies from the effects of the constitutional irritation or poisoning produced by it. There is no difference between the characters of the distant gangrene itself and those of local gangrene, although the causes which produce them are different. The particular study of the causes of this form of distant gangrene finds its natural place with the subject of wounds and injuries of the bloodvessels.

CHAPTER III.

SECONDARY HÆMORRHAGE AFTER GUNSHOT WOUNDS.

This complication is always an alarming one to patients and a source of great anxiety to surgeons. In occasional instances, when a large vessel is the source of it, secondary hæmorrhage occurs so suddenly and so profusely that the result is very quickly fatal; and in almost every case it is a symptom indicative of a hazardous condition of the patient. It is by no means an unfrequent complication of gunshot wounds. It is particularly liable to occur in wounds which are attended with sloughing action, and especially when the sanitary state of the hospitals in which the wounded men are treated is bad, or the wards are overcrowded. Under the last-mentioned circumstances secondary hæmorrhage is also not an unfrequent complication after amputations which have been performed on account of gunshot injuries.

Modes in which it shows itself.—The manner in which secondary hæmorrhage occurs differs in different cases. In some instances an indication of its approach is given to the surgeon by the escape of a small quantity of blood, the flow of which may either stop spontaneously, or be temporarily arrested by appropriate means. This flow may then recur after a time, increasing in quantity, until at last the necessity for active surgical interference is thoroughly indicated. Or, instead of this happening in moderate amounts at successive times, a copious flow may suddenly take place from a wound without any previous warning, and the patient's life be placed in immediate danger unless steps can be taken at once to avert the threatened fatal result.

Frequency of its occurrence.—It has just been remarked that gunshot wounds are not unfrequently followed by secondary hæmorrhage. As with other complications of these injuries, so with this, exact information cannot be afforded respecting the proportionate number of cases in which it has hitherto occurred, either when regarded as an average, or on particular occasions. The deaths which are due, either directly or indirectly, to secondary hæmorrhage are shown in army numerical returns under the name

of the original injury, or under that of the amputation or other surgical operation which has succeeded it. Hence some surgeons write of secondary hæmorrhage as being more frequent than others report it to be; the impressions respecting its frequency being derived from the varying experience of the different observers. And if the opinion regarding the general causes which lead to its prevalence be correct, it may be readily understood that the experience of different observers as to its relative frequency will differ greatly according as the circumstances under which the injuries have been treated have differed.

Period of its occurrence.—Secondary hæmorrhage is understood to mean that which takes place subsequently to the time at which primary hæmorrhage has been arrested, whether by natural or artificial means; or, in cases where no primary hæmorrhage of moment has occurred, subsequently to the time at which such hæmorrhage ordinarily happens. The period during which secondary hæmorrhage may occur may be more or less remote; it may vary from a few days to three weeks or more after the infliction of the wound.

It is necessary to distinguish between simply recurrent, or delayed primary hæmorrhage, and secondary hæmorrhage. It sometimes happens in field surgery that the ligature placed on a wounded artery hastily, and perhaps imperfectly, at a dressing station, will become loosened, or altogether detached, during the subsequent movements of the patient while he is being carried, not improbably in unsuitable transport conveyances, to hospitals placed at a distance in the rear; or the clot by which a vessel has been temporarily occluded may be forced away by the jolting to which the patient is subjected, and, under the influence of the pain and excited arterial action which arise in consequence of this disturbance, the hæmorrhage which had stopped may break out afresh. Not unfrequently, also, after the arrival of wounded men at the field hospitals, vessels which had not bled previously, owing to the condition of shock or faintness under which the patients had laboured, together with the effect of the open air upon their wounds, will commence to bleed because the circulation has become more active under the influence of warmth and the restorative remedies administered; or, under similar reaction, arteries which have been completely divided but temporarily stopped by coagulum and the other usual natural means of arresting hæmorrhage in the early stage of the process, may become reopened and give rise to fresh hæmorrhage through the effects of the increased force and pressure of the arterial stream. Cases have also occurred in which divided vessels have been temporarily occluded by the very projectiles which have injured them, and have bled copiously when these foreign bodies have been taken away. These occurrences, though not immediately following the infliction of the wounds from which they

are derived, are manifestly not cases of secondary hæmorrhage. They may be called intermediate, but they neither differ in their nature, nor in respect to the condition of the parts concerned, from cases of primary hæmorrhage.

Dr. Thomson has stated in his Report of Observations made in the British Military Hospitals in Belgium after the battle of Waterloo,[1] that, judging from notes in his possession of above 50 cases which occurred among the wounded at that time, secondary hæmorrhage is most liable to occur after the twentieth day from the date of the original wound, but he was doubtful whether this represented the general period of its occurrence. In many of the cases referred to by Dr. Thomson, however, the hæmorrhage arose from sloughing of arteries occasioned by hospital gangrene. In others the hæmorrhage was of the capillary kind, that is, was not due to escape of blood from any particular vessel obvious to view, but occurred apparently as an effect of generally increased determination of blood to the walls of the canals of gunshot wounds, or of the surfaces of stumps after amputation. Dr. Thomson ascribed the hæmorrhage in the last class of cases to accidental circumstances, such as the injudicious administration of too liberal an allowance of stimulants and animal food to patients of a plethoric temperament; but, although this may have been the exciting cause among the wounded in the Belgian hospitals, it is certain that a form of secondary hæmorrhage, having precisely similar characters, was frequently met with during the Crimean war under very opposite conditions. Secondary discharges of blood, in the form of capillary oozing, were frequently witnessed in the Crimea among the wounded, when the men had become so reduced in constitutional tone by the trying circumstances of the siege, especially during the first winter and ensuing spring, that no surgeon could have thought of resorting to the antiphlogistic methods of treatment recommended by Dr. Thomson, as the results of his Waterloo experience, for their prevention or alleviation.

Special varieties of secondary hæmorrhage.—Attempts have been made by several military surgeons to allot different periods of time for the occurrence of particular varieties of secondary hæmorrhage. Dr. Thomson, to whose experience among the wounded in Belgium reference has just been made, divided secondary hæmorrhage into three periods, and allotted special causes to each period. Secondary hæmorrhage of the first period, or from the second to the fifth day, he ascribed to the recently closed mouths of arteries being opened by increased force of circulation; of the second period, from the fifth to the tenth day, to ulceration or sloughing of the coats of arteries, most frequently to sloughing; while he regarded the secondary hæmorrhage of a still later period, between the twentieth and thirty-fifth day, as either capillary or occasioned by hospital gangrene. Guthrie has stated that secondary

hæmorrhage, whatever the cause, usually occurs between the beginning of the second and the fourth week,[5] that is from the eighth to the twenty-eighth day. Hennen and other army surgeons have named other periods when secondary hæmorrhage may be expected. From the discrepancies in the statements on this point it is obvious that there is a difficulty in assigning limits of this kind with precision; and, considering the very different causes to which the complication may be due, and the accidental nature of some of them, it may reasonably be expected that some degree of uncertainty must always exist regarding the time of the occurrence, no less than on the occurrence itself, of secondary hæmorrhage. No wounded patient, indeed, can be considered to be safe from secondary hæmorrhage happening so long as his wound, if it be a deep one, and especially if it has been complicated with fracture of bone, remains open.

Local causes of secondary hæmorrhage.—Secondary hæmorrhage may have either a local or general origin, and it becomes important to separate the two kinds of causes when the question of treatment is considered. Among the local causes may be enumerated cases of ulceration of a ligatured vessel due to excessive disturbance of the connections of the vessel, and interference with the means of the proper maintenance of its vitality, at the time of the application of the ligature; too strong an application of a ligature, so that the outer coat of the vessel has been partially divided at the time of the operation, and the ligature becomes detached before the hæmostatic process has become completed; or too loose an application of the ligature, so that the vessel has not become properly sealed at the time of its detachment; ulceration or sloughing of the coats of the vessel, as a consequence of original injury done to it by the projectile to which the wound itself is due; the same accident owing to erysipelatous inflammation in the neighbourhood, diffused areolar suppuration, or spread of gangrene among the textures in the neighbourhood of the vessel and the invasion of tissues immediately adjoining it; too dependent a position of the wounded part, or accidental injuries in the course of treatment; and, lastly, the continued pressure of a lodged projectile against a vessel, or the action of a sharp point or edge of a fragment of a projectile, or spicula of fractured bone, leading to penetration of a vessel. Of these local causes of secondary hæmorrhage probably the most frequent is that in which a vessel of considerable size has been severely contused by a passing projectile, so that ulceration, or sloughing of its coats, occurs subsequently. In these cases the hæmorrhage does not usually take place until a week or so after the receipt of the wound: probably not till some time in the course of the second week after it, when suppuration has become fully established and sloughs are being thrown off from the surrounding tissues. But a sudden start of the patient, or some excessive

exertion, or passionate excitement, may bring on the hæmorrhage at any moment, when the parts are in a favourable condition for its occurrence. This equally applies, however, whether the tendency to the secondary bleeding have its origin in local or constitutional causes.

General causes of secondary hæmorrhage.—Among the general causes of secondary hæmorrhage, all those diseased conditions of the constitution may be included which induce such a deteriorated state of the blood as lessens its coagulability and unfits it for performing its part in the process of hæmostatic repair. Again, all those circumstances may be reckoned as general causes of secondary hæmorrhage which so frequently occur in campaigning, by which a scorbutic taint is induced. Whenever this state of system has been engendered, the constitutional powers are lowered to such an extent as to impair the vital energy of the arteries themselves as well as of the tissues immediately surrounding them; and hence that portion of the process of obliteration of an artery, which depends on the effusion and consolidation of healthy lymph within and around the vessel, the importance of which in securing it against secondary hæmorrhage has been so well shown by Professor Spence, is impeded or altogether prevented. Secondary hæmorrhage under such circumstances is an almost inevitable occurrence. It is often difficult in field practice to determine how much such accidents are due to a merely depressed state, how much to a poisoned state, of the patient's circulation. In general, when troops are subjected to excessive fatigue and exposure, and are at the same time ill-nourished, the hospitals from these very causes become simultaneously overcrowded; so that, while on the one hand the men are deprived of their natural vigour and power of resisting disease, on the other hand they are placed in a vitiated atmosphere, and are subjected to circumstances which are especially favourable to its development and spread. When men thus debilitated become the subjects of gunshot wounds, and are so housed for treatment, the instances of secondary hæmorrhage may be expected to increase in number in proportion to the intensity of the two agencies under notice. General oozing of blood may equally be looked for from the faces of stumps after amputation, and great difficulty may be experienced in finding means of permanently arresting the flow. If the hæmorrhage be recurrent and considerable in amount, the already depressed vital power of the scorbutic or blood-poisoned patient becomes lowered in a rapidly increasing ratio by the repeated discharges of blood and the unhealthy conditions by which he is surrounded, and he sinks, either with symptoms of general exhaustion, or of fully developed septicæmia or pyæmia.

Secondary hæmorrhage as a sequence to venous thrombosis.—Dr. Stromeyer has particularly pointed out the frequency with

which secondary bleeding occurs in subjects of gunshot wounds of the extremities in whom bloodvessels have been injured, when some of the principal veins of the extremity in which the wound is situated have become obstructed through the occurrence of thrombosis, and the circulation of the whole limb has in consequence become more or less impeded. He has shown that under such circumstances the hæmorrhage may be either arterial, venous, or capillary. It matters not whether the source of the venous obstruction be pyæmic or have a local origin; according to Dr. Stromeyer, the bleeding is equally liable to occur, whenever the general mass of blood has not been so lessened, through previous loss of blood or profuse suppuration, as to make the pressure of the circulation too weak to give rise to hæmorrhage. The healing process which may have commenced, or have advanced considerably, retrogrades, and the injured vessels, which had already become closed, then reopen.

CHAPTER IV.

INVASION OF GUNSHOT WOUNDS BY MAGGOTS.

Flies in camp and tropical hospitals.—A repulsive complication not unfrequently met with in the treatment of gunshot wounds in time of war, is one which is rarely brought to notice in the treatment of wounds in civil practice, viz., the presence of maggots. In camp hospitals in warm weather, and in all hospitals in tropical climates, wherever many wounded men are congregated, flies collect and increase with wonderful rapidity. The greatest diligence is necessary to counteract the constant efforts of these insects to deposit their ova in the openings of gunshot wounds, and to prevent the generation of larvæ in them, especially while sloughs are in process of separation. It is easy to understand why such occurrences are rarely met with in hospital buildings in England. Not only is the necessity for general cleanliness and for guarding against the access of flies to wounds properly appreciated; but, owing to the coolness of the climate, the flies themselves exist in comparatively small numbers in such places. It is easy enough, therefore, to protect sores and wounds from them. In former days larvæ, as a complication of wounds, appear to have been common enough, even in England, if we may judge from the records of them in old surgical works and the number of remedies advocated for their removal: so common, indeed, that '*Ulcera Verminosa*' was a term in ordinary use. The granulations of a wound appear to offer a very favourable situation for hatching the ova of flies: the

moisture, warmth, and softness seem to suit their development. Both in healthy suppurating gunshot wounds, but especially in wounds from which sloughs are being thrown off, the odour not improbably attracts the flies to them for the deposition of their ova. Maggots, however, do not confine themselves only to wounds about which there is a certain amount of putridity; they are liable to be met with in wounds which are quite free from sloughs.

Plague of flies in the Crimean hospitals.—In camps flies seem to find the tents convenient places of shelter, especially double tents, such as hospital marquees; for they settle in large numbers on the inner lining of the roof. In the Crimea, for a certain season, the flies abounded in such numbers as to constitute a terrible plague. It seemed impossible to keep them in check. Though the wooden huts and tents were on a bare elevated plateau, surrounded on two sides by open sea, so that it might well have been supposed the wind would have swept them altogether away, yet the flies were everywhere in myriads during the hot weather, and no plan seemed to succeed in reducing their numbers. They literally swarmed about the beds. If they were driven from one patient they simply settled on another. All that could be done was to try and protect the wounds and sores from inroads of the flies, but although constant care and watchfulness were exerted by both surgeons and attendants for the purpose, their efforts were attended with only partial success. One advantage of marquees over wooden huts at this season was that the evil could be mitigated to a certain extent in them when a breeze was blowing, for the walls of the marquees could be raised, and thus a current of air be obtained over and around the beds on which the wounded patients were lying. But even in these at night, or during the early morning, while the tents were closed up, some of the flies would descend, and either from the dressings getting partly removed through the restlessness of patients, or in some other way, they would contrive to find access to the wounds. The 'plague of flies' is adverted to in the official report of the Crimean war, and the difficulty of devising means for ridding the wounded from it is thus described: 'The most scrupulous attention to the immediate removal of all dressings and bloody cloths, whether dry or recently stained, the most rigid enforcement of cleanliness, and the burial of all offal or refuse in the neighbourhood, failed, however, to do more than check the evil, and many and various plans were resorted to, first to prevent the deposit of the eggs, and, secondly, for the destruction of the larvæ, if they had gained access.'[6]

Irritation of wounded men caused by flies.—The mischief which is done to wounded men, when flies abound in such numbers as they usually do in camp hospitals in warm weather, is not confined to the fact of their depositing ova and generating maggots in the wounds, though this is repulsive enough both to the patients

and their attendants. They produce pernicious effects in other ways. By settling on the faces or on other exposed parts of patients as they lie in their beds, they become constant sources of irritation, deprive the patients of their proper amount of rest and sleep, and thus often seriously impede the progress of their cure. The multiplication of flies is, therefore, an evil to be guarded against, and every pains should be taken to prevent their lodgement and accumulation in the neighbourhood of wounded men.

During the mutiny campaign in India in 1857 and 1858, as might have been anticipated under the circumstances of a tropical climate where insect life is so rife, the flies were a source of great misery to the British troops. Dr. Brougham, in his account of the Siege of Delhi in 1858, remarks of the flies:—'This awful plague was beyond credence. I have seen them breed in the mouths, noses, and even in the urethræ and arms of the wounded. How they penetrated even into the urethra is a mystery, but there could be no doubt of the fact, for in one instance the sufferer was unable to pass water until six maggots were extracted from the passage.'[7] This fact sufficiently shows the rapidity with which the larvæ must have been developed.

Species of flies which infest wounds.—In the Crimea and in India the fly commonly observed was apparently of the same species as the common housefly met with in England. There is another species of musca in India to which wounds may be subjected, the larvæ of which do not appear to be so easily destroyed as those of the ordinary domestic fly. An interesting report of a case, in which death resulted from an Indian species, the *sarcophaga ruficornis*, has been described by Staff-Surgeon Stewart in the 12th Volume of the 'Army Medical Reports.' But the larvæ ordinarily met with in wounds in India, as well as in temperate climates, are those of the ordinary *musca domestica*. Baron Larrey, in his account of the Egyptian Campaign under General Bonaparte, refers to the frequency of the larvæ of the common blue fly in the suppurating sores of the wounded. He describes the maggots as being formed in a few hours, and mentions that they increased in size so quickly that in the course of twenty-four hours they equalled the quill of a fowl in diameter. He remarks that the incubation of the eggs deposited by these flies in the wounds and dressings was not only favoured by the hot and moist atmosphere, but also by the quality of the material used for the dressings, which was cotton instead of linen, the latter not being procurable in the country; while the continued speedy reproduction of them after the destruction of those in the sores, was attributable to deficiency of the necessary means for keeping off the approach of the flies and so preventing the deposition of fresh ova. Notwithstanding the irritation and itching caused by the presence of the larvæ in the wounds, and the increased labour from the necessity of changing the dressings three

and four times a day, Larrey discovered an advantage from their presence. They accelerated the cicatrisation of the wounds, he writes, by abridging the work of nature and provoking the detachment of the sloughs of the cellular tissue which they in part devoured.[8]

CHAPTER V.

HOSPITAL GANGRENE AFTER GUNSHOT WOUNDS.

ONE of the gravest and most destructive complications to which gunshot wounds are subject is Hospital Gangrene. This complication has been described under various designations: under names expressive of some of its characteristic features, as Phagedæna Gangrænosa, and Putrid Ulcer of Wounds; Hospital Gangrene, Hospital Sore, Pourriture d'Hôpital, pointing to its special habitat, viz., hospitals where many wounded patients are crowded together; Gangræna Contagiosa, from a belief by some that the direct local application of a special poison is essential to the production of the disease; Typhus des plaies, Typhus traumatique, or Wound-Typhus, by others who have supposed the disease to be a local manifestation of the effects of the same poison as that which shows itself constitutionally in persons without wounds under the name of Typhus Fever; and Diphthérite des plaies, or Wound-Diphtheria, from the peculiar membranous exudation by which some forms of the disease are characterised.

Former types of hospital gangrene in military hospitals.—Army surgeons of the present day have had but few opportunities of becoming familiar with hospital gangrene in the extremely virulent epidemic form under which it formerly presented itself: because, on the one hand, the principal causes of the disease, and, therefore, the means of preventing it, have been better understood; and, on the other, the means of arresting its progress, when it has broken out, have been more adequately apprehended. It is to the writings of a former generation of surgeons that the enquirer must turn for descriptions of the disease in its most aggravated characters. During the Peninsular War, hospital gangrene attacked the patients in some of the British military hospitals in Spain, Portugal, and the Netherlands, and spread among them with frightful intensity. Several of the medical officers, who practised in these hospitals have left records of their observations and experience, particularly Dr. Hennen, Dr. Blackadder, Dr. Boggie, and Mr. Guthrie. Mr. Guthrie has put on record the number of cases which occurred at the station hospitals in the Peninsula between the 21st of June and the 24th of December, 1813. By this return

it appears that 1,614 cases of hospital gangrene, mostly from Vittoria, were treated at Santander, Bilbao, Vittoria, and Passages, and that of this number 512 died, 980 survived to be discharged from hospital, and 85 were still under treatment at the close of the period named.[9]

Hospital gangrene prevailed among the wounded after the battle of Waterloo at Antwerp, and, after a time, in some of the hospitals at Brussels. It committed severe ravages among the British wounded in the Sikh Campaigns of 1845. The description of it by Inspector-General Taylor, as it occurred in the 29th Regiment at Ferozepore in India, has been published by Mr. Guthrie.[10]

Hospital gangrene in British hospitals during the Crimean war. Hospital gangrene was not one of the diseases from which the wounded of the British army suffered in the Crimea. There were, as before mentioned, not wanting numerous cases of extensive sloughing and ordinary traumatic gangrene; but of true contagious hospital gangrene, not only did it never occur endemically, but in only one hospital did it appear at all, and that to a very limited extent. Certainly no instance of it occurred in any of the hospitals with which I was acquainted during the entire war. The immunity of the British hospitals in the field from hospital gangrene was the more remarkable as the disease prevailed extensively in some of the French military hospitals during the Crimean war.

The exceptional instance above-mentioned occurred in the hospital huts of the 79th Highlanders, where typhus fever was rife at the time. It was referred to by Dr. Goldie Scot, surgeon of the regiment, in his monthly report for March 1855, in the following terms: 'A bad form of phagedænic sloughing occurred in the hospital, which appeared to be contagious; and had many wounded existed at the time in the regiment they would have fared but badly. They were, however, few in number, and consequently only one case of gunshot wound died from the disease. It attacked every variety of wound indiscriminately, from a cut finger to an open bubo.' The hospital huts, and those in which the men of the regiment, who had but little rest from very harassing duties at the time, habitually lived, were placed under very unsanitary conditions. The ground on which the huts were erected consisted of plastic and very retentive clay; there was no system of drainage; the huts were sunk from two to three feet in the ground, and were situated close to the breastwork. The suggestions, which the surgeon made to avert or mitigate these deleterious circumstances, were not adopted; they were considered to be impracticable for strategic and engineering reasons.

The state of the hospital at the time this outbreak of hospital gangrene occurred is so forcibly depicted by Dr. Scot, a very accomplished and painstaking medical officer, and the description seems to explain so sufficiently the causes of its appearance, that I

insert the account in his own words: 'From the 1st to the 15th of April, the endemic of remittent typhus was at its height. The horrors of that period can never be effaced from the memory of those who had to cope with its difficulties. The hospital huts were unavoidably much overcrowded, and the means of attendance were quite inadequate. The two assistant surgeons were lying prostrated by fever. No less than three non-commissioned officers, who had in succession taken the duties of hospital sergeant, were attacked by the disease; and orderly after orderly succumbed to its virulence. Fortunately I was enabled to struggle on to the 16th, when, exhausted by bodily fatigue, and driven nearly to despair by anxiety, I was attacked by the fever, which nearly proved fatal. I had, however, the satisfaction of knowing before I was taken ill that the long-desired and frequently-urged measure, which strategic reasons had prevented from being adopted at an earlier date, of moving the hospital and regiment, was to be carried out. Almost every case of fever this month assumed the maculated typhus form, and I can safely affirm the disease was never seen in a more virulent form than that in the hospital of the 79th Regiment. A few of the men were quite idiotic for weeks after recovery, and hallucinations of the most extraordinary character were very common.'

Extensive bedsores, and a tendency to sloughing phagedæna formed a distressing complication of the disease. The vitality of the patients was in many instances so reduced that sloughing was produced by very slight causes. Blistered surfaces invariably sloughed, and, in one instance extensive sloughing of the scalp was caused by shaving the head with a blunt razor. Several small cuts had been made accidentally, around each of which phagedænic action arose, and a large slough formed.

It can hardly be doubted that the same causes which led to the production of the typhus fever, combined with the overcrowding of the patients in the hospital huts, gave rise to the tendency to phagedæna, and conferred on it the virulent characters which it presented; and there can be equally little doubt that, as Dr. Scot observed, had many wounded men been brought within the sphere of the hospital atmosphere, few, if any, would have escaped from being attacked by the hospital gangrene.

In the early period of the war many of the wounded who were conveyed from the Crimea to the general hospitals at Scutari and Malta became subjects of a form of gangrene which was probably closely allied to true hospital gangrene. It broke out in the overcrowded sailing transports in which wounded men were too often placed close to one another in tiers between decks, without adequate ventilation, and without the dietary, hospital attendance, appliances, and changes of dressings which the nature of their cases required; while, at the same time, there was a great amount of mechanical irritation of the wounds themselves from the movements inseparable

from the situation of the patients on shipboard. Gangrene also prevailed in the large hospital at Scutari during the winter of 1854–55, when, for a time, its crowded and unsanitary condition might apparently have well led to the development of the disease in its most virulent and aggravated form. Yet it never acquired this intensity, and indeed the gangrene at Scutari seems to have been destitute of the contagious and infectious qualities, and to have been deficient in other characteristics of true hospital gangrene. The following remarks, taken from the description of it by Dr. Macleod, who witnessed the disease, seem to confirm this statement:[11] 'During the first winter hospital gangrene prevailed a good deal in a mild form at Scutari, but it never became either general or severe. It did not appear to pass from bed to bed, but rose sporadically over the hospital. It frequently attacked the openings both of entrance and exit, but occasionally seized on one only, showing apparently a predilection for the wound of exit. At times it showed itself only in part of a wound, and spread in one direction alone. It appeared chiefly in the lower extremities, and in wounds whose progress towards cure had been for some time stationary. It seldom burrowed far into the intermuscular tissue, but confined its ravages to the surface and the circumference of the wound. I never saw any marked gastric disturbance attend it. If it attacked the wounds of those already labouring under fever, it appeared to aggravate the fever. Those who had suffered in camp from diarrhœa, and whose strength had been much reduced, more especially those whose constitutions were strongly impregnated with scurvy, were most liable to be attacked; and in all our cases, so far as I saw, the development of the disease resulted from a lowered state of general health more than from specific causes.'

Hospital gangrene in French hospitals during the Crimean war. Hospital gangrene, described by M. Legouest to have been contagious both mediately and immediately and by inoculation, prevailed epidemically among the wounded in the hospitals of the French army, both in the Crimea and at Pera, as well as in the ships conveying them to the latter place and to France. M. Legouest says that it was severe during the whole period of the war in the East (1854–56), with an intensity more in relation to the number of patients admitted into the hospitals and ambulances than to the seasons of the year. He also remarks that it showed itself during the Italian campaign, in the spring and summer of 1859, in proportions less considerable than in the East but still in a very lamentable degree, and that it also existed during the whole duration of the war in France in 1870–71.[12]

Hospital gangrene in India.—Since the Crimean war, one of the severest occurrences of hospital gangrene in an endemic form in the British service occurred in India, in the besieged residency of Lucknow in 1857. Hospital gangrene attacked nearly every one

who was wounded, and proved fatal to a large majority of the number. Dr. Arthur, surgeon of the 1st Madras Fusileers, has given a copious and instructive account of this epidemic of hospital gangrene and its causes. After General Outram's arrival with the relieving force in September 1857, the position occupied by the troops besieged in the residency was considerably extended. On this account the duties continued as severe as they were before the arrival of the additional troops. The numerous outposts and guards could not be relieved. The men had to sleep on their posts, and, having little bedding, they suffered from cold during the night, and disease was the result. Moreover, a considerable number of wounded men were brought into the garrison at the time of the entry of the relieving force. The hospital accommodation was bad, as well as the sanitary state of the garrison. Not only were the hospitals generally crowded, but some of them had to be barricaded to protect the patients from the enemy's fire. The rules of ventilation, cleanliness, and the application of disinfectants, could not be properly enforced. The want of a nutritious diet and sufficient amount of stimulants, as well as of all comforts and conveniences, further lessened the chances of recovery among the patients. Few wounds consequently healed without sloughing, and many took on a form of hospital gangrene, which could only be arrested by the free application of strong nitric acid. Dr. Arthur records his belief that not one instance of a successful case of amputation of the thigh or leg occurred throughout the siege. Many cases appeared to progress favourably for four or five days, and even partial adhesion would take place; the patient would then probably have a rigor or two followed by febrile excitement, thirst and irritation of stomach; the flaps would swell open and assume a dark sloughy aspect, and the patient would speedily sink and die. Some cases of amputation of the arm succeeded, but very few even of them. Towards the termination of the siege, amputation was only performed when no hope remained without it. Sometimes a slight scratch or contusion would become a large sloughy or gangrenous wound. No wound, however simple, could at the commencement be pronounced to be without danger. Major S.'s wound appeared at first to be a slight contusion on the abdomen from a bullet, but grangrene ensued and it proved fatal.[13]

Hennen's description of hospital gangrene.—When premonitory symptoms usher in an attack of hospital gangrene, they are not unlike those which precede an attack of erysipelas, but they present themselves in a more aggravated degree. Dr. Hennen[14] has distinguished three stages of the disease; and, with regard to the first or incipient stage, he says:—'Let us suppose that our wounded have all been going on well for several days, when suddenly one of our most promising patients complains of severe pain in his head and eyes, a particular tightness about the forehead,

want of sleep, and loss of appetite, and these feelings are accompanied with quickness of pulse and other symptoms of fever; his wound, which had been healthy and granulating, at once becomes tumid and dry, and painful, losing its florid colour, and assuming a dry and glossy coat.' According to Dr. Hennen, the disease was generally under control in this incipient stage, but if it were overlooked, then the second stage rapidly supervened. 'The febrile symptoms very soon became aggravated; the skin around the sore assumed a higher florid colour, which shortly became darker, then bluish, and last black with a disposition to vesicate; while the rest of the limb betrayed a tendency to œdema. All these threatening appearances occurred within twenty-four hours; and at this period also, the wound, particularly if it were situated on a muscular part of the thigh, buttock, or calf of the leg, whatever might have been its original shape, soon assumed the circular form. The rapid progress and the circular form of the ulcer were highly characteristic of the hospital gangrene, and obtained almost universally in every wound infected with it, wherever situated. The discharge in this second stage became dark-coloured and fetid, and the pain was extremely poignant. The gangrene still advancing, fresh sloughs were rapidly formed, the increasing cup-like cavity of the ulcer was filled up and overtopped by them, and the erysipelatous lividity and vesication of the surrounding skin gained ground, while chains of inflamed lymphatics could be traced from the sores to the adjoining glands, there exciting inflammation and suppuration, which often formed a new nidus for gangrene. The face of the sufferer assumed a ghastly anxious appearance, his eyes became haggard and deeply tinged with bile, his tongue loaded with a brown or blackish fur, his pulse considerably sunk in strength and proportionately accelerated.' Dr. Hennen then describes at some length the remarkable impatience of pain and depression of spirits, which all the patients, even the bravest soldiers, exhibited during the progress of the disease.

In the third and last stage, 'the surface of the sore was constantly covered with a bloody oozing, and, on lifting up the edge of the flabby slough, the probe was tinged with dark-coloured grumous blood, with which also its track became immediately filled; repeated and copious venous bleedings now came on, which rapidly depressed the patient still further; the sloughs, whether falling off spontaneously or detached by art, were quickly succeeded by others, and discovered on their removal small thickly studded specks of arterial blood. At length an artery sprung, which, in the attempt to secure it, most probably burst under the ligature; the tourniquet, or other pressure, if now applied, was vain, for while it checked the bleeding, it accelerated the death of the limb, which became frightfully swelled and horribly fetid. Incessant retchings soon came on, and with coma, involuntary stools, and hiccough, closed

the scene. Often, however, the patient survived this acute stage of the disease, to sink under severe irritation, absorption of putrid matter, and extensive loss of substance, without any other symptoms than those of hectic fever arising from other sources.'

Dr. Hennen's experience of hospital gangrene was principally obtained in a large military hospital near the town of Bilboa, of which he was in charge in August 1813. There were a thousand patients in the building, all labouring under wounds which had mostly resulted from the battle of Vittoria. According to Dr. Hennen's description, the position of the hospital, which was situated about six miles from the Bay of Biscay, and the building itself, were to all appearance exceedingly favourable for the accommodation of the patients; the weather was mild at the time the hospital gangrene first appeared; but there were deficiencies in respect to many needful appliances. There were no bedsteads, bedding was extremely scanty, and Dr. Hennen remarks, 'the wounded lying on straw spread upon the floors, and very much crowded together, was one cause, no doubt, of the rapid progress of the contagion.'

Early symptoms of the disease.—It will be observed that in the description of this outbreak of hospital gangrene, Dr. Hennen places very distinctly the constitutional symptoms before the appearance of the changes in the wound itself. Sir James McGrigor, whose opportunities of forming an opinion on the subject at this period were also very extensive, seems equally to have come to the conclusion that constitutional disorder preceded the local symptoms.

All observers have not agreed in these respects. Mr. Blackadder, in his remarks on the disease, which he also saw in Spain, has stated that he did not observe in any one instance the constitutional symptoms precede the local,[15] and that it was not till the third or fourth day that the constitution exhibited signs of irritation. He regarded it as a local disease 'sui generis'—the result of a specific poison. Mr. Copland Hutchinson and some other observers, French as well as English, have also maintained the view of the disease first appearing as a local affection. These discrepancies in the statements of close and experienced observers lead to the inference that there is no fixed order of procedure in the local and general phenomena of hospital gangrene, or that the constitutional premonitory symptoms may sometimes be so slight as to escape notice. Mr. Guthrie, indeed, who had great personal experience of the disease during the Peninsular War, has asserted that sometimes the constitution and sometimes the local symptoms take the precedence, the order varying according to climate, season, and other circumstances. His description of the appearance and progress of a wound poisoned by hospital gangrene, while equally expressive with that of Dr. Hennen, contains information on one or two points which Dr. Hennen has not noticed. 'A wound attacked

by hospital gangrene in its most concentrated and active form, presents a horrible aspect after the first forty-eight hours. The whole surface has become of a dark red colour, of a ragged appearance, with blood, partly coagulated and apparently half putrid, adhering at every point. The edges are everted, the cuticle separating from half to three-quarters of an inch round, with a concentric circle of inflammation extending an inch or two beyond it; the limb is usually swollen for some distance, of a shining white colour, not peculiarly sensible except in spots, the whole of it being œdematous or pasty. The pain is burning and unbearable in the part itself, whilst the extension of the disease, generally in a circular direction, may be marked from hour to hour; so that in from another twenty-four to forty-eight hours, nearly the whole of the calf of a leg, or the muscles of a buttock, or even of the wall of the abdomen, may disappear, leaving a deep great hollow or hiatus, of the most destructive character, exhaling a peculiar stench which can never be mistaken, and spreading with a rapidity quite awful to contemplate. The great nerves and arteries appear to resist its influence longer than the muscular structures, but these at last yield; the largest nerves are destroyed, and the arteries give way, frequently closing the scene, after repeated hæmorrhages, by one which proves the last solace of the unfortunate sufferer. I have seen all the largest arteries of the extremities give way in succession, and till the progress of the disease was arrested by proper means, the application of a ligature was useless. The joints offer little resistance; the capsular and synovial membranes are soon invaded, and the ends of the bones laid bare. The extension of the disease is, in the first instance, through the medium of the cellular structure of the body. The skin is undermined and falls in, or a painful red and soon black patch or spot is perceived, at some distance from the original mischief, preparatory to the whole becoming one mass of putridity, whilst the sufferings of the patient are extreme. A complaint of this kind cannot long be local, even if a local origin be admitted; the accompanying fever is usually dependent on the previous state and general constitution of the patient, modified by the season of the year, or the prevailing type of febrile diseases.'[16]

Such is Mr. Guthrie's description of hospital gangrene, as he observed it during the war in the Peninsula, and the account is sufficiently formidable. In the milder forms, when a case takes a favourable turn, the amendment may be observed to commence five or six days after the beginning of the attack. The pain in such an instance becomes less, the discharges lose their odour, and become more healthy in consistence and appearance, the turgid and dark red integument which surrounds the diseased part becomes more bright, and assumes a condition of healthy inflammation, while the wound or sore regains its normal tendency to granulation and cicatrisation. This favourable change rarely takes place unless the position and

circumstances of the patient are altered from what they were at the time he was first attacked; if, however, the improvement should happen to occur without such an alteration, there must always be a great liability to fresh accessions of the disease.

Varieties in hospital gangrene.—Several varieties of hospital gangrene have been recognised. M. Delpech described three forms of the disease, viz., the ulcerative, the pulpous, and the gangrenous: the first-named being the least active and least destructive form, the two latter the graver forms of the disease, but all three liable to succeed each other in the same wound or sore. These divisions are generally accepted by French military surgeons of the present day. M. Legouest, acting on observations of the disease in the French hospitals during the Crimean war, has described two other forms in addition, which he designates the gelatinous, and the gelatinous hæmorrhagic: the former occurring when the exudations assume a colloid and partly translucent character; the latter being named from the sanguineous infiltrations with which these colloid exudations are occasionally mingled, especially in patients of a scorbutic taint. It is chiefly in the pulpous form of hospital gangrene that the false membranes are produced which have originated the name of 'wound diphtherite' for the disease. The granulations of the surface of the wound in this variety first become dull and turgid in appearance, and are then covered by a layer of white or ash-coloured exudation with dark points, which quickly increases in thickness and consistence; thus differing from what M. Delpech described as the ulcerous form of the disease, in which no other covering is left on the surface than a sanious discharge. This false coating is strongly adherent to the granulations beneath; it can be peeled off them like an elastic false membrane, though with difficulty, and not without giving rise to oozing of blood from their surface. When this coating has acquired a certain thickness, it softens down, becomes putrid, and emits a horribly fetid odour. If this be removed, a fresh layer of false membrane may be found beneath to go through a similar transformation; or, without this occurring, there may proceed a rapid mortification and softening down of the connective tissue in all directions; or all the structures may become involved in the gangrenous form of the disease. Both the pulpous and the gangrenous forms are accompanied with intense pain.

Different symptoms of hospital gangrene and simple gangrene.—Hospital gangrene differs in several respects from the complication of simple gangrene elsewhere described. The manner in which it attacks a wound and the rapidity with which it destroys the integrity of the surrounding structures, more particularly the connective tissue; its capability of propagation from person to person; the circular outline which the diseased action generally assumes as it spreads; the severity of the attendant pain; its special effects on

certain structures, such as its invasion of arteries without causing thrombosis—these are all circumstances which cause it to fall within a distinctly separate category from ordinary gangrene.

Various modes of origin attributed to hospital gangrene.—It has been mentioned that some surgeons regard hospital gangrene as originating in a local poison, these forming the majority; and that others have considered it to be attributable to the influence of a constitutional poison.

The following are some of the considerations which have weighed with surgeons who regard the disease as having a local origin. In the first place, it seems to be an established fact that hospital gangrene may be communicated to a wound in a healing condition or to a simple ulcer in a patient of good constitution and good general health, by the direct contact of sponges, charpie, bandages, lint, and other articles, which have been impregnated with the discharges from another wound or sore affected with the disease. In like manner a slight wound or abrasion in the hand of a surgeon may become affected with the disease through touching a wound affected with hospital gangrene; or a puncture by an instrument soiled with the matter discharged from such a wound will suffice to propagate its kind, even though efforts may be made to escape from its noxious effects, not only by local treatment, but also by going away to a situation where the air is of the purest character.

In the year 1810, M. A. F. Olivier of Paris, then a young man, allowed himself to be inoculated in the right arm with matter from a bad case of hospital gangrene. He was in good health, and went into a pure atmosphere away from the neighbourhood where hospital gangrene was existing. By the fifth day the part had assumed all the characteristic features of hospital gangrene, when M. Olivier interrupted the progress of the sore by removing the sloughs and applying strong nitrate of silver. Assistant Surgeon Blackadder [17] became the subject of it by accidentally puncturing himself in one of his fingers, while examining the stump of a patient who had died from the effects of the disease. M. Legouest mentions that several of his subordinates contracted the disease in the East in consequence of pricking their fingers with pins while fastening the dressings of the wounded.[18] Sir George Ballingall has related an occurrence, which was told to him by Deputy Inspector General Marshall, strongly illustrative of the production of hospital gangrene by direct local poisoning.[19] Gangrene became prevalent in a regimental hospital at Faversham in 1806, and some men who had been flogged died from the lacerations of the skin becoming attacked by the disease. It was then discovered that all the cases had been bathed by the same sponge: this was destroyed, no more sponges were permitted to be used, and the gangrene ceased. Mr. Holmes Coote mentions that during an out-

break of hospital gangrene, which took place in the year 1846 in St. Bartholomew's Hospital, 'the extension of the disease was clearly traced in two instances to the use of a sponge which had been first applied to a gangrenous sore, then boiled, and afterwards applied to a healthy wound.[20]

A striking recent illustration of the contagious nature of the disease as it occurred at Bonn during the late war between France and Germany was mentioned by Mr. A. E. Barker, in a paper read before the Surgical Society of Ireland in 1873.[21] Mr. Barker was in charge at Bonn of certain patients affected with the disease after they had been isolated for treatment. The gangrene only manifested itself among the patients of one particular surgeon, whose dressers, Mr. Barker remarked, could not be said to be of cleanly habits. In the case of one patient who had arrived at Bonn with a perfectly clean-looking amputation wound of the thigh, a ligature, which was still adherent to a large artery on the inner aspect of the stump, was removed, and the hospital gangrene commenced distinctly at that spot. 'In this case the thread was removed by the surgeon in attendance on the other cases of gangrene, whose hands may have conveyed the poison whatever it be.' The cases attacked were 'lying in a room with about ninety other wounded men, and yet only those subjected to the manipulations of one set of dressers were attacked.' As soon as perfect isolation of the patients suffering from the disease was established, the gangrene ceased to spread.

The power that discharges from wounds affected with hospital gangrene have of disseminating the disease is so persistent, that ordinary means of purification do not suffice to destroy it. Hennen, quoting from a paper by Professor Burgmanns, mentions that in the year 1797, a quantity of charpie was bought in France and distributed for use to different hospitals in Holland. In every case in which it was employed for dressing sores violent hospital gangrene broke out. It was subsequently discovered that the persons who sold it had been in the habit of washing and bleaching charpie that had been previously used in hospitals, and of then selling it as new. The statement that the poisonous quality of the discharges is not destroyed, although the articles which have absorbed it may have been washed, boiled, bleached, dried, and stored away for a considerable time, is very important from a practical point of view. The statement agrees with the results of experiments, published a few years ago,[22] which seemed to prove that the poison of putrid animal substances is not a volatile but a fixed one, and that it is not destroyed by boiling, nor even by evaporation to perfect dryness: for, on being dissolved in water, and a small quantity of the solution being injected into the veins of an animal, this desiccated putrid extractive matter sufficed to produce the characteristic symptoms of septicæmia.

Some facts tend to show that the poison of hospital gangrene,

if the existence of a special poison be admitted, may be communicated by the emanations from wounds affected with the disease floating in the atmosphere. This would be as truly a local application as if the poison were applied by the direct application of some of the discharge on a sponge or piece of charpie. A striking fact, which seems to point plainly to this mode of transmitting the seeds of hospital gangrene, has been recorded by Dr. Hennen.[23] It is mentioned by him in the following words: 'At the end of the summer of 1798, in a French military hospital at Leyden, hospital gangrene prevailed in one of the low wards, whilst the patients who had slight wounds, and were placed above this ward in a well-aired garret, were found to escape the disease. The surgeon judged it necessary to make an opening in the floor of the upper room, in order by that means to afford an outlet through the roof to the air of the infected ward below. Thirty hours afterwards three patients who lay next to the opening were attacked by the disease, which soon spread through the whole ward.' In this instance the position of the patients who were first attacked, the rapidity with which the gangrene followed the opening of communication with the infected ward, and the concurrent appearance of the disease in several patients, appear to leave little room for doubt that the diseased action was induced by the topical effects of the air, or rather of septic emanations wafted upwards by it as it rose from the ward below. Its subsequent diffusion through the whole ward might be explained as having been due to mixed causes.

Mr. Blackadder, who was a strong believer in the contagious character of hospital gangrene, was no supporter of the opinion of its infectious nature. He says that, so far as he had had an opportunity of observing, ninety-nine cases in the hundred were evidently produced by a direct application of the morbific matter to wounds through the medium of sponges, tow, water, instruments, and dressers; and he certainly adduces some remarkable illustrations of the escape from the disease of wounded patients in beds adjoining those in which other patients with hospital gangrene were lying, when rigid measures were taken to prevent all direct contact or intercourse between them.[24]

Those surgeons who have been led to attribute the origin of hospital gangrene to constitutional causes have arrived at this view from the difficulty of explaining some of the features of the disease by local poisoning; but more especially from noticing that constitutional symptoms have preceded the local symptoms in certain cases. The difference in the views held as to whether the origin be a constitutional or a local one is not unimportant in practice; since one view points to constitutional remedies being the most likely to prove efficient means of treatment, the other that local protection and local treatment are alone likely to be of avail.

Dr. Chenu, admitting that sometimes the local and sometimes

the constitutional symptoms are first manifested, has been led to associate these facts with other phenomena; and has come to the conclusion that they are characteristic of two distinct forms of hospital gangrene, essentially different in their nature, gravity, mode of progress, and the treatment required for their cure. He describes hospital gangrene, in which the local signs are first manifested, as 'true hospital gangrene' (Pourriture d'hôpital vraie, franche). The disease which is preceded by general symptoms he designates 'Pourriture d'hôpital non franche.' The former he subdivides, following the description of Delpech, into three varieties—ulcerous, pulpous, and gangrenous; the latter also into three varieties, which he designates—pultaceous, pulpo-membraneous, and diphtheritic. The former, according to his views, absolutely requires local energetic treatment to arrest it; the latter principally requires internal remedies, and only very mild applications locally.[25]

Whether there is so marked a discrepancy between hospital gangrene when the local signs are first manifested, and hospital gangrene preceded by general functional disturbance, as to warrant their separation into distinct species, as Dr. Chenu has separated them, admits of much doubt. The several varieties have been observed so frequently to pass into each other, and the different phenomena connected with them seem to have been so much associated with differences of constitutional states of patients, and especially with variations in the circumstances under which they have been placed, and under which the disease has been contracted, that it is questionable whether these conditions do not supply a sufficient explanation of the deviations in the phenomena presented by the several forms of the disease under notice.

Conditions which lead to the development of hospital gangrene.—Military experience has sufficiently established the fact that there are certain conditions which generate a predisposition to hospital gangrene, and materially assist in its development, if they do not generate the poison itself.

In all the instances in which hospital gangrene has appeared in a virulent epidemic form, there has been, at the beginning, an overcrowding of wounded men with suppurating wounds in respect to the space in which they have been accommodated. This defect can scarcely be avoided under the occasional accidents of military operations; but formerly it seems to have been the rule, instead of the exception, in military hospitals. It is this circumstance which has caused hospital gangrene to attract so much notice in connection with military practice. There have been civil hospitals within comparatively recent times which have never been wholly free from hospital gangrene owing to original defective construction, and to their position among a dense population; but, from the limited numbers of wounds or sores in the building to be attacked by the disease, it has not assumed a virulent epidemic character, and has

not therefore excited special remark. The effects of overcrowding wounded men together, if the aggregation be excessive, cannot be counteracted by free ventilation; such a forcible perflation of air would be required to dilute and carry off emanations with the necessary completeness that it could not be borne by the wounded with impunity. If, together with overcrowding, the supply of fresh air be insufficient; if the rooms in which the wounded men are placed be small with low ceilings; if the air be allowed to become infected, through want of cleanliness on the part of the patients, in their bedding, in the ward utensils or appliances, through bad drainage or other sources of hurtful effluvia in the vicinity of the hospital buildings; then, even more certainly, may hospital gangrene be looked for as likely to attack the wounded patients.

The situation of a hospital on low flat ground near a river, or in a marshy district, appears to act as a predisposing cause of hospital gangrene and to excite a proneness on the part of the patients to be attacked by it. After the battle of Waterloo, the disease prevailed much more at Antwerp, the situation of which is very low, than at Brussels, which is comparatively high. All the worst cases at Brussels were in the old or lower part of the town. The disease assumed an intense form in a hospital about two miles from Brussels, where the Brunswickers were treated: nearly every patient on whom amputation was performed died from it. This hospital was situated on a thickly-wooded swampy flat, through which the great Antwerp canal was cut.[26] The only outbreak that occurred in the Crimea took place in a hospital, the surgeon in charge of which, as before-mentioned, attributed the disease in a great measure to the damp and undrained soil on which the hospital was placed.

The position of the wards in which the patients are treated exerts an influence on the tendency to the disease. It has been noticed that an outbreak of hospital gangrene has usually commenced in the lowest rooms of the building in which the wounded have been collected. This is probably attributable to the fact of these being the rooms in which there is least movement of air, owing to the obstruction of walls, streets, and adjoining buildings; while they are most exposed to the reception and influence of noxious effluvia from the surface of the ground, from privies and cesspools, and other such sources.

A high degree of temperature seems to favour the appearance and spread of hospital gangrene, though it occurs at all seasons of the year. The worst epidemics recorded by British surgeons have taken place in fixed hospitals during the heat of summer. If the high temperature be combined with dampness of soil and a still atmosphere, the circumstances are still more favourable to the development of the disease. In open campaigning in tropical climates, where the field arrangements have generally admitted of

so much wider a distribution of patients in tents or comparatively open bungalows, hospital gangrene in an epidemic form has been rare. But under other circumstances, when troops have been closely confined, as they were at Lucknow in 1857, or when the wounded have been placed in considerable numbers in walled hospitals near native habitations, it has assumed a most virulent type in India.

There seems to be no doubt that all causes which depress the spirits of soldiers predispose to hospital gangrene, as they do to other diseases of a similar type. That this should be so, is not antagonistic to the fact that wounded men in the highest state of general health, when exposed to the disease by contagion or infection, are liable to be directly attacked by it. It was observed after the battle of Waterloo that the despondency resulting from defeat caused the spread of hospital gangrene, and the number of deaths resulting from it to be greater among the French prisoners than among the British wounded at Antwerp. The mental depression produced by defeat is, in such cases, added to the bodily depression which invariably follows the excitement caused by the active operations of a campaign among men who are suddenly reduced to complete inactivity by wounds, and, at the same time, placed under the unfavourable influences of the trying scenes inseparable from a crowded hospital. The bodily fatigue and pain endured by wounded soldiers who are subjected to long transport in wheeled conveyances, as well as the injury often done to the wounds themselves by the movement, must also be taken into account among the other causes predisposing to this disease.

Conclusions regarding hospital gangrene as it occurs among wounded men.—A review of the circumstances under which hospital gangrene has been observed in military hospitals seems to warrant the following conclusions:—

1. Hospital gangrene is essentially a product of an excessive aggregation of wounded men under unsanitary circumstances in fixed or floating hospitals. It has not generally appeared until some time after they have been collected together: after the atmosphere has, in fact, become vitiated to such an extent as to become a source of septicæmia. Whatever adds to the stagnation of the atmosphere also assists the onset and march of the disease.

2. All causes which have a tendency to exert a depressing influence, bodily or mental, on the men before being wounded, or which depress them after having been wounded, predispose them to be attacked by hospital gangrene, and help the disease to assume a greater virulence of character.

3. When hospital gangrene has been developed, the disease can exert its specific noxious influence either by local absorption of its products at the surface of a wound, or, if sufficiently concentrated, by absorption of them through the lungs in respiration.

4. When hospital gangrene is communicated locally, it is sometimes excited by the action of its peculiar products through the direct application of them from other wounds already affected with the disease; at other times by the contact of emanations arising from them and floating in the atmosphere.

5. When hospital gangrene is communicated constitutionally, or by absorption in respiration, all that is necessary is a certain concentration of the putrid animal emanations in the atmosphere: the degree of concentration necessary to produce this effect probably varying according to the state of health and powers of resistance of the patients.

6. In military practice endemic visitations of hospital gangrene have been generally due to both the local and general causes combined:—to septicæmia arising from the circumstances in which the wounded soldiers have been placed, and to diseased action excited in the wounds themselves by local contagion, the sources of which have been already enumerated.

CHAPTER VI.

PYÆMIA AFTER GUNSHOT WOUNDS.

A large proportion of the deaths from gunshot wounds in recent campaigns, from the Crimean war downwards, have been ascribed in military professional returns to pyæmia. This source of mortality was not mentioned in the Peninsular or Waterloo returns. Pyæmia may be defined to be a systemic disease of very fatal character supervening on a suppurating wound, and usually marked by the formation of abscesses in some of the viscera, or in parts of the body at a distance from the wound itself. Some consider it to be identical with erysipelas, and with septicæmia; but, though pyæmia has many features in common with these diseases, it seems better to regard it in the present state of our knowledge as a separate and special disease.

Occurrence of remote abscesses after wounds.—The development of abscesses in parts of the body at a distance from some particular spot in which inflammation and suppuration had occurred after an injury, had long been known, and is occasionally referred to in the works of very early writers. The occurrence was explained by those who adopted the humoral views regarding the nature of disease as a translation of the puriform matter itself from the place it had previously occupied to its new situation; while those who referred diseases chiefly to alterations of the solid parts of the body, attributed it to transference of the irritative action which had

originally produced the morbific matter. The particular channel along which the puriform fluid, or the irritative action, was conveyed, was not explained; it was simply described as a change in the seat of the disease, and hence the term then employed of 'abscess by metastasis.' This doctrine was opposed by John Hunter. In his work on the 'Blood, &c.' he strongly repudiated the possibility of a quantity of pus being carried, or transferred, from one part of the body to another.[27] It does not appear that in the beginning of the present century any special connection had been observed between wounds of the extremities and distant deposits of pus. As examinations after death became more frequent and more carefully instituted, the occasional existence of deposits of pus in the joints, the principal viscera of the abdomen and thorax, and of effusions into the pleural cavities and peritoneum, after gunshot and other wounds of the extremities and after amputations, gradually attracted attention. Mr. Guthrie, in his 'Commentaries on the Surgery of the Peninsular War,' ascribed their occurrence to the effects of phlebitis, and claimed to be the first who had pointed out the intimate relationship between this disorder and the secondary deposits referred to. Baron Larrey noticed the occasional formation of abscesses in the liver, after injuries to the bones of the upper and lower extremities, but more especially after gunshot wounds of the head. The army surgeons engaged in the Schleswig-Holstein campaigns of 1848 to 1861 appear to have arrived at the conclusion that pyæmia was a consequence of phlebitis, the same as some of the English surgeons of the Peninsular period had come to. Dr. Esmarch, in his 'Treatise on Resection in Gunshot Injuries,' founded on observations in the Schleswig-Holstein campaigns where pyaemia was said to be of frequent occurrence, has remarked: 'We generally found the cause of pyæmia to be inflammation of the veins. It is especially from the veins of the bones upon which this infection proceeds, &c.' Dr. Stromeyer, who was Surgeon-in-Chief of the Schleswig-Holstein Army in the campaign of 1849, remarks in his 'Treatise on Fractures of Bones from Gunshot': 'I have many times convinced myself that the pus first passes into the larger veins out of the osseous substance, and thence reaches the general circulation.' Pyæmia is recorded as having been a frequent cause of death in the British official report of the surgery of the Crimean campaign, but it is not attributed to the effects of phlebitis. On the contrary, it is stated that, though secondary purulent deposits were far from an uncommon accompaniment of pyæmia, post-mortem examinations rarely revealed any inflammation of the venous canals, and when any evidence of such inflammation was found, it usually consisted of the exudation of more or less perfectly organised lymph. In exceptional cases, when the formation of pus had actually taken place within the canal of a blood-vessel, the matter

was mostly isolated and cut off from communication with the blood by a deposit of plastic material around it. The greater number of French surgeons, however, appear to have regarded pyæmia, or as it was more frequently called by them 'purulent infection,' both in the Crimean and in the subsequent Italian war, as a result of the secretion of pus in the veins and its subsequent mixture with the blood in circulation.

Mortality from pyæmia among the wounded in Paris in 1870-71. The proportion of deaths from pyæmia during the late siege of Paris appears to have been unusually great. Surgeon Macdowall, of the Indian army, who was in Paris during the whole of the siege, and who acted as a volunteer surgeon in the French hospitals, has recorded that 'the mortality from pyæmia and hospital gangrene amongst the wounded and amputated during the siege of Paris is known to have been greater than has ever occurred before in the annals of military surgery.' And again, 'pyæmia was the almost universal cause of death in all the wounded, and was so without exception in amputations, even at the American tent-ambulance, where the treatment was almost open-air treatment.' Dr. Demarquay, one of the most distinguished surgeons and men of science in Paris, told Surgeon Macdowall that 'he had not succeeded in saving a single case of amputation at the newly planned and constructed wood-hut hospital at Passy.' The eminent Dr. Ricord described the ravages of pyæmia in this hospital, large and well-ventilated as it was, as fearful. This scourge of the military hospitals increased in severity as the duration of the siege increased. Dr. J. Worms, the Sanitary Commissioner of Paris, told Dr. Macdowall that 'in round numbers all the cases of amputation in the last few weeks of the siege died; that the result was the same with nearly all corresponding cases in which the operation was not performed; and that these deaths were almost all from purulent infection. Surgeon-General Gordon also, in his report on military surgery during the siege of Paris, has stated: 'the prevalence of purulent infection increased as the siege went on, and the wounds became more numerous; also, it must be observed, as the fatigue, exhaustion, and the moral effects of repeated want of success became more and more pronounced.' Surgeon-Major Wyatt also, in his report on the siege, writes of the constant prevalence of purulent infection, and of the usually fatal issue of the disease when thoroughly manifested.

Wounds specially liable to pyæmia.—Any wound in which the process of suppuration is going on seems to be capable of inducing the peculiar febrile state which precedes the purulent collections and effusions of pyæmia; but certain species of wounds seem to be more liable to the supervention of this affection than others. Gunshot fractures of bones in which great comminution has occurred; amputations of limbs through the shafts of bones opening their

medullary cavities, particularly if the operation is performed when the medullary membrane is in an inflamed state; and wounds of the head in which the cranium is implicated, especially when any of these wounds occur in men whose strength has been reduced by much hæmorrhage, or other depressing circumstances; appear to present conditions more favourable for the development of pyæmia than simple flesh wounds, removal of portions of limbs through joints, or wounds involving the chest or abdomen.

Symptoms of pyæmia.—The symptoms of pyæmia are by no means uniform, and the period at which they may arise after injuries is also very uncertain. The symptoms may appear shortly after suppuration has been established, but in military practice it is more commonly met with in the later stages of wounds. The subject of pyæmia, who may have apparently been progressing quite favourably and feeling confident of recovery, is generally seized with an attack of shivering. This takes place, perhaps, after a disturbed and restless night. Alternate chills and febrile heats follow, with excessive perspirations, headache, great exhaustion, and general aching and uneasiness. All appetite for food is lost. The patient's countenance becomes very anxious, his spirits are depressed, and he becomes despondent about the issue of his wounds. He may be observed to turn about frequently; his pulse is rapid, irregular, but readily compressible; the skin is sallow, of a dusky, jaundiced hue, and sodden from the profuse sweating. His breath has a peculiar odour, which hardly admits of correct description, but which, once smelt, is readily recognised again. The parts adjoining his wound assume an unhealthy œdematous appearance. If the suppuration has been previously healthy in character, the discharge becomes thin and ichorous, and is deficient in quantity; or the wound may seem to be stationary, so that its surface becomes dry. The edges of the wound usually exhibit a flabby half-dead appearance, and have a tendency to gape; the skin immediately surrounding it is probably injected and turgid. The temperature is high. Perhaps, commencing inflammation in some of the serous membranes may now be observed, either over the brain, or in the chest or abdomen; or the usual symptoms of effusion may be indicated, with scarcely any trace of local inflammatory action preceding the appearance of the collected fluid. Or the patient may suddenly complain of pain like that of rheumatism in one or more joints, which rapidly become swollen, perhaps red on their surfaces, and exhibit the characteristic features of fluid effusion into their synovial cavities. In some joints the appearances may be those of simple synovitis, in others those of suppurative inflammation. There may be fulness and tenderness on pressure in the hepatic region; or disordered respiration, dyspnœa, cough, and other signs usually indicative of sub-acute lobular pneumonia, may be the most marked symptoms

presented. In one case at Fort Pitt I saw the globes of both eyes rapidly destroyed by suppuration. Again, there may be dark bilious purging, or there may be copious discharges from the bowels of a serous or mucous character without much admixture of bile, according as the liver or bowels are the parts to which the excess of action is determined. As the disease advances, the features become pinched, and strikingly rapid emaciation attracts notice; there is probably diarrhœa; profuse perspirations, increased exhaustion and debility occur; no sleep can be induced; and finally, stupor, delirium, and other typhoid symptoms announce the close approach of the fatal termination.

Re-separation of united gunshot fractures from pyæmia.—Another mode in which the effects of pyæmia may be occasionally exhibited in military hospitals is the following: A case of gunshot fracture of the shaft of a bone may progress favourably, a considerable quantity of callus having been thrown out and consolidation to a great extent effected, when suddenly pyæmia supervenes, and all this advance towards union recedes, the ends of the broken bone again become detached and loose, and a fatal result follows. A striking instance of this retrograde action, consequent upon a subacute form of pyæmia, came under my notice in the Crimea.

Corporal B., 19th Regiment, aged 19 years, of good health and strong frame, had his left thigh bone comminuted at the attack on the Redan on the 8th September, 1855, by a rifle bullet. The missile struck the shaft near its centre. There was no doubt that the bone was much split, and that amputation, if performed, would have to be done close to the trochanters. In consequence of the very unfavourable results which had attended amputations in this situation, and considering the youth and good constitution of the patient, I determined to try and save the limb. The case progressed favourably for some time. Some dependent incisions had to be made to facilitate the escape of pus, and to effect the removal of detached splinters. At the end of October consolidation had so far advanced that the patient was able unassisted to raise the limb a short distance up from the bed on which he was lying. On the 2nd November, however, without any apparent cause, he was seized with rigors and vomiting; profuse bilious diarrhœa followed, and, though checked after a time, continued to recur at intervals up to the date of his death. The discharge from the wound became excessive in quantity, of thin consistence, dark colour, and offensive odour; the fractured ends of the bone became loose and movable; the patient very despondent; he had a quick, small pulse, and suffered from chills, followed by fever and profuse night sweats, as if he were suffering from a complication of ague, of which, however, there was no previous history. Then great œdema of the injured extremity appeared, with excessive general prostration, and the patient expired on the 1st of December.

Attempts were made, by the free use of stimulants and appropriate medicines, to bring the patient's constitution into a state offering a favourable prospect for secondary amputation of the limb, but without success. At the post-mortem examination, all the muscles of the thigh presented a peculiarly pale, flabby, œdematous aspect; the structures around the seat of fracture, and for some distance from it, upwards and downwards, were in a semi-sloughy, softened condition; and the connective tissue of the whole limb was infiltrated with ill-conditioned purulent fluid, without any apparent effort to circumscribe it.

Dr. Esmarch records an acute case very similar in its results. A Schleswig-Holstein soldier had both his left femur and left humerus shattered by musket bullets. At first the case proceeded favourably, and the humerus was consolidated in the third week without the removal of a single sequestrum. The femur also seemed inclined to heal, although the bullet remained in the wound; but, in the fourth week, the discharge became sanious. Pyæmia developed itself from this time, and soon proved fatal. During the last few days the fracture of the humerus again gave way. At the autopsy, it was found that this bone, in its middle, was in eight large splinters, of which five were already firmly united to the lower, and three to the upper fragment, by means of a considerable mass of callus. This callus was evidently reabsorbed at the spot where the splinters had been mutually united, and thus the continuity had been again broken.

Modes of death in pyæmia.—When pyæmia runs on to a fatal termination, and this is its usual result within a period of four to eight days, death may occur in several ways. It may either happen from cerebral excitement, succeeded by coma; or the patient may sink under the direct effects of visceral disorders, as when extensive lobular pneumonia, gangrene of the lungs, or empyema have resulted. Death may take place rapidly by paralysis of the nervous centres; or under symptoms of fever of a typhoid character; or, where the pyæmic abscesses are so placed as not to interfere seriously with the more important vital functions, the patient may sink more slowly from exhaustion, hectic, or seemingly worn out by the effects of excessive diarrhœa.

Nature of pyæmia.—The complex symptoms which characterise pyæmia have led to a great variety of theories for their explanation. The term pyæmia, or pus-poisoning of the blood, sufficiently shows the opinion which originally dictated it. But though pyæmia, in all probability, depends upon some change in the constitution of the circulating fluid of the body, scarcely any one now believes that true pus, in its uncorrupted state, can be absorbed into the circulation and be the source of this change. Like the doctrine of metastasis, or change of seat of pus from place to place, as formerly held, the notion of pus circulating through

the arterial system in this disease, whether as a consequence of Phlebitis or otherwise, is now almost universally abandoned. By most surgeons the disease is attributed to the absorption by the living tissues of some septic material, the particular nature of which is yet to be discovered, but which appears to be derived from purulent discharges in a decomposed or partially decomposed condition. The manner in which pyæmia may be communicated from patient to patient by using the same sponges or materials of dressings, its tendency to prevail in buildings which have been previously for some time in use as hospitals for the treatment of wounded, and many other such circumstances, favour this idea.

Whatever the particular nature of the poison of pyæmia may be, one among its other effects is to cause the fibrin of the blood to separate from its other constituents and to be deposited in some portions of the vascular system; or else to induce a tendency to coagulation of the blood at the seat of injury or in some other situation. Hence one of the most frequent phenomena accompanying pyæmic disease is the formation of clots or thrombi in some of the veins. The detachment of fragments of these clots, carriage of them into the general circulation, and their subsequent impaction at some parts of the circulatory system where the arteries become too small to permit the clots to pass on, lead to the phenomena of embolism. The obstruction of the vessel by the clot or embolus leads to the deprivation of a particular part of the body of some of its normal supply of blood; and in this part inflammation and suppuration are consequently excited, a pyæmic abscess is formed, or, occasionally, gangrene results. Thrombosis and embolism thus together become leading causes in the production of the purulent collections which constitute some of the most remarkable features in the pathology of pyæmia.

But the purulent collections, which are met with in pyæmia, cannot always be traced to the origins just named. Sometimes they take place with a rapidity, and in such a diffuse way as to exclude embolism from being concerned in their production. Several joints remote from each other will become tender and swollen together, and in two or three days, without marked disease of cartilage, or any other disorganisation, they will be distended with fluid of a purulent character. Diffused collections of sero-purulent fluid with almost equal suddenness will spread through the connective tissue of one or more limbs, or will accumulate in one or both of the pleural cavities. Multiple abscesses will form in the liver or lungs, and yet no signs of embolic mischief may be traceable in these organs. The fact that an embolic source is not discoverable is not of course a sufficient proof that no such origin has existed; but the absence of the appearances of embolism that are occasionally found elsewhere, and particularly the rapidity with which these collections sometimes form (a rapidity which

chiefly led to the old supposition that collections of pus were capable of suddenly changing their situation) certainly favours the supposition that they are occasionally formed independent of any such origin.

Association of pyæmia with gunshot wounds of bones.—There appear to be several reasons why pyæmic action is more likely to follow gunshot wounds of bones than injuries of other parts. The prolonged duration of the suppurative action while sequestra are being detached, and the formation of new bone is proceeding; the long period of confinement in a hospital atmosphere, to which the patient is necessarily subjected; the frequency with which an extension of the suppurating action takes place along the medulla and substance of the bone, as a consequence of osteo-myelitis; the obstructions which are apt to exist in these structures and to cause imprisonment of the pus, so that its constant free escape is not permitted, as in wounds of the softer parts; the facility which is gradually acquired for the pus to burrow along and between the inactive muscles, so leading to its being retained among them for long periods; the readiness with which pus becomes decomposed when air, particularly foul air, has access to it; these constitute one set of causes of the liability to pyæmic poisoning after such injuries. The peculiar circumstances of the venous system in bones, especially the situation of the vessels in unyielding hard canals, so that their extremities after division are apt to remain patulous, seem also to favour its occurrence. Unhealthy puriform fluid, detached particles of disintegrating tissues, and septic agents when from any cause decomposition of the discharges is induced, are more likely to pass along them into the general circulation, than they are along veins of the soft parts which may collapse, or become closed by pressure from surrounding structures, after similar gunshot injuries. After wounds of the head, in which the vascular system of the diploë is involved, a tendency follows to the formation of thrombi in the sinuses of the dura mater; and, in case of its occurrence, as these softened down, or as portions of them became detached, the particles would readily pass to the right side of the heart, and so to the finer ramifications of the pulmonary arteries. The stretched condition of the sinuses between the membranous laminæ of the inelastic dura mater, causes them to correspond with veins of bones in respect to their persistent patulous condition. When pyæmia follows injuries of the head, the pyæmic foci are almost invariably found in the structure of the lungs, and this is a result of the facts just mentioned.

Prevalence of pyæmia in military hospitals.—There is this peculiarity connected with gunshot wounds in military hospitals, that usually many of them (and a large proportion of them always consist of fractured bones) occur at the same time. Hence a ward may be filled with cases in all of which suppurative action is pro-

ceeding. Under such circumstances a condition of atmosphere is easily produced that must act deleteriously in a direct manner upon the constitutions of the patients. Septicæmia, varying in degree according to the amount of concentration of the ward emanations in the atmosphere, is the result. The depraved state of the patient's blood induces an alteration in the very nature of the pus discharged from his wounds; and one leading feature of this change probably is that the pus contains within itself the elements of its own more speedy decay than happens in normal pus. It is more easily acted upon by any ill-conditioned influences to which it may be subjected; its proneness to putrefaction is increased. This disposition of the discharges to take on the process of decomposition at once finds an agent ready to set it in action in the impure atmosphere with which the wounds are brought into contact. It has been well established that if one patient suffering from pyæmia is placed in a ward where there are many other patients with suppurating wounds, a considerable proportion of the latter will almost certainly become infected with the disease. It has also been remarked that when patients with fresh wounds are admitted into hospitals which had been used for the wounded from previous battles, especially if any patients with suppurating wounds still remain in them, the new comers become much more than ordinarily exposed to the liability of pyæmia. This can only be accounted for by supposing the hospital to be tainted by emanations from the previous patients, and by purulent matters, in a more or less advanced state of decomposition, concealed in the walls, floors, and ward furniture; not forgetting, at the same time, the well-known tendency for such septic matters to set up a corresponding septic action, or tendency to decomposition, in all the substances which are liable to be affected by them. It must also be remembered that any circumstances which tend to irritate a suppurating wound (and suppurating wounds, in which the jagged ends or splinters of broken bones are implicated, are particularly liable to be so irritated) assist in inducing the development of pyæmia. Irritation of this kind is particularly likely to occur when wounded men have to be transported long distances, and especially when the means of transport are not favourable.

It is, indeed, almost impracticable under the ordinary circumstances of warfare to procure the absolute rest necessary for patients with fractured bones; and equally so, with deficient numbers of surgeons and attendants in proportion to those of patients, with improvised, and too often unsuitable and ill-supplied hospitals, to obtain that perfection in sanitary arrangements which is essential for the prevention of the causes which favour the development of pyæmia. No one who is familiar with the usual state of hospitals, especially of the temporary field hospitals, and with the difficulties in the way of ensuring the requisite cleanliness

of patients, attendants, and hospital surroundings, in a country where military operations are in progress, need look farther for causes of septic disease, and for pyæmia as one of its manifestations among men under treatment for suppurating wounds.

Conclusions regarding pyæmia in military practice.—To judge from observation in military practice, it would seem as if it were almost necessary that two conditions should co-exist in order for pyæmia to be developed: viz., the process of suppuration in the patient, and some agent, such as an impure condition of the atmosphere in which the patient is placed, capable of corrupting the pus, and converting it into a source of septic poisoning. If a patient suffering from an ailment or injury, unattended with suppuration, be placed in an impure ward in which many suppurating wounds are under treatment, he may possibly become affected with typhoid symptoms, or some other form of septicæmia, but there is no probability of his becoming the subject of secondary pyæmic abscesses; and again, if a patient with a suppurating wound, however tedious and prolonged in its process, be placed either by himself or only with patients suffering from internal diseases, in a pure and well-ventilated ward, the occurrence of pyæmia is in this instance an equally improbable event. It does occur occasionally under such circumstances, and sometimes where we might least expect it, in isolated cases and in private dwellings where cleanliness and ventilation appear to be fully provided: but probably, if the conditions of such cases could be thoroughly ascertained, there would be found something defective in one or other of the following respects:—Either the apartment has been made nearly air-tight, or what is called free from draughts and comfortable, especially at night, and in this condition has been pervaded by some deleterious gas or effluvium; or pus has been retained, and, if not actually decomposed, has become modified in some of its healthy characters and vitiated: or some neglect as to the purity of the things around the patient has occurred; and thus the materials for inducing septicæmia have been allowed to develope themselves and to accumulate until they have rendered the wound unhealthy and have poisoned the patient.

The prognosis in regard to pyæmia when it occurs in military hospitals in the field, is unfavourable in the extreme. It is one of the most fatal of all the complications to which wounds, not otherwise of a fatal character, are liable in military practice. Indeed, when pyæmia is thoroughly manifested, it is doubtful whether it is ever checked in its deadly advance. In cases where the signs of pyæmia exhibited are comparatively slight, where rather a tending towards the affection is shown than the affection itself, no doubt, on appropriate measures being adopted without delay, restoration to a healthy condition is from time to time witnessed. The full development of the poisonous influence appears to be pre-

vented in these exceptional cases; and it follows, therefore, that it is of essential importance to watch and grapple with the disease at its earliest onset. But under the too frequently unfavourable conditions of hospitals in time of war, the occurrence of well-marked pyæmia supervening on a gunshot wound can be hardly regarded otherwise than as sealing the fate of the patient.

CHAPTER VII.

TETANUS AFTER GUNSHOT WOUNDS.

This is probably the most distressing to witness of all the complications with which a gunshot wound may be attended. Few patients survive in whom this morbid condition is thoroughly established; and, irrespective of the consciousness of the little power that surgical art possesses to control the intense sufferings which it entails, it is all the more painful to contemplate, because even in the most violent forms of the disease the intellect of the patient remains perfectly clear almost to the end.

The term 'tetanus' in army nomenclature, is not limited to contraction and rigidity of the voluntary muscles of the whole body, but also includes the various localised forms of the disorder: *trismus*, or rigidity of the elevator muscles of the lower jaw, which is usually observed in all cases; *opisthotonos* of the extensor muscles, the most common of special tetanic contractions; *emprosthotonos*, of the flexor muscles; and *pleurosthotonos*, rigidity of the lateral muscles of the body. The two forms last named, especially the last, have been but rarely observed. Larrey's large experience of traumatic tetanus in his numerous campaigns, led him to conclude that, when the wounds which are followed by this disease affect nerves of the anterior region of the body, emprosthotonos takes place; if nerves of the posterior parts of the body are wounded, opisthotonos occurs; if the wound involves both anterior and posterior parts, general tetanus is the result. Although either opisthotonos or emprosthotonos may be the most marked features of an attack of tetanus, however, the disease is generally attended with contractions, more or less noticeable, of all the voluntary muscles of the body.

Tetanus more frequent in former than in recent wars.—General remarks in military surgical histories sufficiently show that tetanus followed gunshot wounds formerly far more frequently than it has done in the wars of recent years. Reliable numerical data are not available, however, to show what the exact amount of difference has been in this respect. The difficulty in arriving at precise information on the subject arises from the fact before referred to,

that the numerical returns employed in time of war show the injuries for which patients are admitted into the hospitals, but not the immediate causes of death when the cases terminate fatally. Thus, the returns show the number of patients admitted with gunshot wounds, and the number of deaths consequent on them, but not the number of cases in which the fatal results were due to tetanus. The occurrence of tetanus, as of all other special complications, is only made known when special reports are sent on the subject; and all who are acquainted with the difficulties attendant on the process of writing reports under the numerous urgent necessities which press on the time of medical officers in the field, will readily understand how often such notices may be wanting.

War statistics regarding tetanus.—Some examples, however, may be quoted which will sufficiently serve to show the remarkable immunity from tetanus of the men wounded in wars of the present time, as compared with what took place at periods not long removed from us.

Sir Gilbert Blane has stated in his work on 'Diseases of Seamen' that, on the occasion of the victory of Admiral Rodney in the West Indies in April 1782, out of 544 wounded men treated on board ship or in hospitals on shore, 17 died from locked-jaw, while three attacked by it recovered. We thus have 1 in 27 wounded attacked by the disease.[28]

The proportion in which tetanus occurred during the Peninsular War has not been anywhere stated with precision; but, from the sketch of the medical history of the British armies during the Peninsular campaigns by Sir James McGrigor, it appears the number of cases that occurred in the hospitals in Spain and Portugal was very large. 'This very formidable disease,' Sir James wrote, 'has always been prevalent among the wounded after the great battles;'[29] and, further on, he refers to 'several hundred cases' having been detailed.

Sir G. Ballingall, in the year 1838, published a calculation that the number of tetanic cases amongst the wounded of armies was about 1 in 79; and he sufficiently showed that tetanus in its acute and severest form was intended in this remark by adding that 'the proportion of recoveries is so small as scarcely to admit of calculation.[30]

A striking contrast with the estimate of Sir G. Ballingall is presented when we observe the number of cases of tetanus among the wounded in the wars and conflicts which have occurred since the date at which he made his calculation. There do not appear to have been any cases of tetanus among the large number of gunshot wounds which were treated in the hospitals of Paris on the occasion of the insurrectionary outbreak of 1848: at any rate there was not a sufficient number of cases to attract notice. The subject of tetanus was hardly alluded to in the various discussions

which took place at the time in the National Academy of Medicine at Paris on the nature and treatment of the wounds which had resulted from the conflicts. M. Roux, who had charge of a large number of the wounded at the Hôtel-Dieu, into which hospital alone 451 cases were admitted, mentioned he had not had one case of tetanus to treat.[31]

During the Crimean war, which lasted nearly a year and a half, only 24 cases of tetanus supervened on gunshot injuries,[32] 21 in the Crimea, and 3 at Scutari. This number gives only one case of tetanus in every 479 of the total wounded, or 0·2 per cent. M. Scrive mentions that out of 37,537 wounded men treated in the French ambulances there were not more than 30 cases of tetanus. They all terminated fatally.[33] This gives only one case of tetanus in 1,251 cases of wounds, or a little under ·008 per cent. And Pirogoff has recorded that after many inquiries he could only get information of 5 cases of traumatic tetanus in the Russian army throughout the entire war.[34] This would show a very much less percentage even than in the French army, if exact information of the number wounded could be obtained to enable it to be calculated.

During the Italian campaign of 1859, Dr. Chenu states, 153 cases of traumatic tetanus and simple trismus were treated in the hospitals. These seem to comprehend all the cases that occurred among the wounded Austrian prisoners, as well as among the French wounded. He adds that he can only find one case of tetanus, well established, that was followed by cure. It is said, with regard to certain cures related in the reports of Italian surgeons, to be very doubtful whether they were instances of true tetanus.[35] Dr. Demme, who mentions that 140 cases of tetanus came under his cognisance in the various Italian hospitals among the wounded of the three armies, says that of this number, 76 occurred in the hospitals of Brescia, but that these included cases of localised trismus and of so-called rheumatic tetanus, as well as true traumatic tetanus. A table showing the particulars of 92 cases of traumatic tetanus which occurred in the Italian campaign, is printed in Dr. Demme's work. Seven recoveries are shown among the number. Of the 92 wounds preceding the appearance of tetanus, 91 were gunshot wounds, and one was a bayonet wound, the latter being included in the seven recoveries.[36] Dr. Demme estimated the frequency of tetanus in the Italian hospitals at nearly one per cent. among the wounded; but this was probably an exaggeration.

It was mentioned in the United States' Report on the extent and nature of the materials available for the preparation of a medical and surgical history of the War of the Rebellion, that the whole number of cases of traumatic tetanus reported during the war amounted to 363. This number may be changed when the history of the war is completed. Taking as a basis the number of wounds, however, which had been revised in the registers of the

Surgeon-General's office up to the date on which that report was issued, shown at page 6, this would give a proportion of 0·42 per cent.

The only time that tetanus has prevailed among the wounded in British hospitals of late years, has been on the occasion of the mutiny in India in 1857. It was stated to have been very prevalent both among Europeans and Natives at Lucknow during the siege. Dr. Brown, of the Bengal Medical Service, remarks in his notes on the surgery of the Indian Campaign of 1857–58:[37] 'In India, tetanus is much more common than in more temperate climates, and I have little doubt that were the statistics of this campaign made out, tetanus would be found to have caused a great mortality.' But very few observations have been recorded regarding it. Dr. Brougham, in his Surgical Experience of the Siege of Delhi, does not mention tetanus as having been observed there among the wounded.

Not a single case of tetanus occurred among the British troops during the New Zealand War, between the years 1863 and 1867. The hospitals were equally free from pyæmia, hospital gangrene, and other allied diseases. The several facts, just mentioned, tend strongly to confirm the observation previously made regarding the diminution of tetanus, as a complication of gunshot wounds, during recent years among the wounded of armies.

Tetanus in particular regiments during the Crimean war.—It seems curious that out of the 21 cases which occurred among the wounded in the Crimea, during the war of 1854–56, one-seventh of the whole number occurred in the 19th Regiment, of which I was at the time in surgical charge, and a like proportion in the 88th Regiment of the same brigade, and encamped next to it. The fact is the more noticeable, as there was a fourth case of tetanus in the 19th Regiment, though the disease in this instance did not follow a gunshot wound. Thus nearly a third of the total number of cases of tetanus which occurred throughout the war in the Crimea happened in the contiguous camps of these two regiments. Nothing came to my knowledge to lead me to suppose that the 'infection of imitation' exerted any predisposing influence on the occurrence of these cases.

The two regiments were encamped on the west side of the entrance to a long, deep, and narrow ravine—the Karabelnaia ravine; the 19th being the nearest to the bed of the ravine, and, at the same time, receiving some of the surface drainage from the camp of the 88th Regiment, on account of the general slope of the ground. It seemed to me not improbable that damp exhalations from the bed of the ravine, carried along by the strong currents of wind which blew from it, together with variations of atmospheric temperature, were the agents which had the chief influence in producing the disease in the two regiments. All the cases that followed

gunshot wounds in the 19th Regiment, occurred in the month of September 1855, and the case of doubtful origin took place on the second day of the succeeding month. There was a great preponderance of rain during this period. The daily thermometric range was considerable, the air being hot under the influence of the sun in the daytime, but cold and chilly at night. High northerly winds also prevailed during the month of September, and these blew almost directly up the ravine towards the position on which the 19th and 88th regimental camps were placed. At the same time no cases occurred in the 23rd Regiment, which was encamped on the opposite side of the head of the ravine. There was no disease prevalent in the 19th Regiment at the time the cases of tetanus occurred; no deaths took place in it, among officers or men, except from gunshot wounds. All the four cases which happened in the 19th Regiment terminated fatally. In one of the three gunshot wounds the tetanus supervened on a compound comminuted fracture of the right pubis, with a wound of the testicle, caused by grape shot, on August the 26th, 1855. In the second, which occurred on September the 8th, 1855, a rifle bullet entered just above the left knee and disappeared. Seven days after the wound was inflicted, an abscess was opened near the tuberosity of the left ischium, and from this spot the bullet was extracted. Tetanic spasms appeared in the limb on the same day, and gradually spread to all the other parts of the body. The patient died within 72 hours after the tetanus first made its appearance. The bullet was found to have injured the sciatic nerve. It was reddened superficially, and its substance, under a magnifying glass of low power, showed indications of inflammation. A piece of cloth was also found lying midway in the long sinus-like wound made by the bullet. In the third case, which occurred on the same date as the preceding one, a bullet entered the upper and inner aspect of the right shoulder, passed through the axillary region, and made its exit near the inferior angle of the scapula. The nerves apparently escaped lesion. The patient progressed favourably for some days before the tetanus appeared, under which he sank. After death some detached pieces of woollen cloth were found lying entangled among the axillary plexus of nerves. In each of these three cases the tetanus came on in the month of September. In the fourth case, which happened to my own soldier servant, trismus appeared on October the 2nd, 1855. General tetanic symptoms were speedily developed, and the patient died on October the 5th, three days after the beginning of the attack. On trying to discover a local source of irritation, the man told me he had hurt the sole of his foot slightly by the point of a nail about a week before, but I could not then on examination obtain any clear evidence of the injury, nor after death could I find any satisfactory indication of it either. The disease might well have been idiopathic in origin.

All kinds and conditions of gunshot wounds liable to tetanus.—No one kind of gunshot wound, no stage, nor any particular condition of a wound, appears to be more free from liability to tetanus than another. It has been observed in the simplest and in the most complicated wounds: in wounds in an unhealthy, and in others in a healing condition. This fact was fully established during the Peninsular campaign, was pointed out by Sir Gilbert Blane in his observations on the disease as it occurred on shipboard, and has been quite confirmed by subsequent observations. Dr. Brown mentions that, out of six cases that fell under his care in Lucknow, the wounds were granulating in three instances, and were in a sloughing condition in the remainder. A case hereafter mentioned shows that though a gunshot wound may be completely healed, tetanus may still occur. In the majority of the cases which occurred in the Crimea direct injury to nerves preceded the symptoms of tetanus, together with, in some instances, the lodgement of substances which probably acted as sources of continued irritation to them. Of the total 21 cases, ascertained injuries to nerves by gunshot, or by division of nerves in amputation, occurred in 11 cases. In the only case which recovered, the wound was caused by pieces of exploded shell which lodged in the glutæal region. One fragment, nearly a pound in weight, was removed soon after the infliction of the wound, and this was concluded to be the only one which had lodged. Trismus set in seventeen days afterwards, when a further examination of the wound led to the discovery of another fragment of the shell with sharp outlines. It was lodged deeply and rested against the sciatic nerve. When this substance, which was afterwards found to weigh 18 ozs., was removed, the sheath of the nerve was seen to be torn for nearly an inch in extent. The trismus subsided under treatment by calomel and opium to salivation, and the patient gradually became convalescent. In this instance the disease never acquired the extent of general tetanus; but, on the day after the removal of the second fragment, it had so far advanced that trismus was complete, while there was considerable rigidity of the muscles of the limb on the wounded side, and stiffness of those on the opposite one.

Lodged pieces of cloth a supposed exciting cause.—In two of the cases which fell under my own notice in the Crimea, fragments of cloth were found in the wounds after death. In 1861, a French military surgeon, M. Maupin, published an account of two cases of tetanus after gunshot wounds, in both of which the tetanic symptoms seemed evidently attributable to irritation from the lodgement of pieces of cloth.[38] In one, a Quartermaster Sergeant was wounded by a bullet in the right thigh, about four inches below the groin. The projectile passed through the limb, leaving a bridge of five fingers' breadth between the two openings. All went on well till the ninth day, when pain was complained of in and around the

wound. Four days afterwards cramps of the injured limb appeared and symptoms of trismus. The spasms increased, passing to the left lower extremity also, but they still continued more energetic and painful on the wounded side. The whole body finally participated in the spasms, and the patient died on the twelfth day after the first appearance of pain in the wound. After death small pieces of the soldier's trousers and drawers were found lying in the wound. In the second instance, the wound was more in front of the thigh. On tetanus supervening, the track of the bullet was laid open with the intention of destroying the sensibility of the surface by cauterisation. When, however, the track was laid open, a piece of cloth was found to be lying in it. This was removed, no cauterisation was practised, and the spasms gradually ceased.

Nerve lesions alone not a sufficient cause for tetanus.—Cases of tetanus have been recorded in which foreign bodies penetrating nerves, such as a point of broken bone sticking in a nerve, the inclusion of nerves in ligatures applied to vessels after amputation, and other like causes of mechanical irritation, have been found after death, and hence these have been regarded as the causes of the disease. But, though these have been the exciting causes in the particular instances named, and although, as before mentioned, out of the twenty-one cases of tetanus which occurred in the Crimea, wounds of nerves were known to exist in eleven of them, these nerve lesions will not suffice to explain its occurrence, without admitting at the same time either a personal predisposition to the disease on the part of the patients, or taking into account their exposure to general conditions favouring its development. Examples without number of similar injuries to nerves could be quoted without tetanus ensuing as a consequence. A small portion of a bullet has been found firmly imbedded in the radial nerve after amputation of the limb, where the original wound healed without any irritation of a tetanic kind whatever occurring. The amputation was performed, some time subsequently to the wound, for excessive pain in the course of the nerve, and was followed by instantaneous and permanent relief. On dissection the radial nerve was found blended with and intimately attached to the cicatrix of the wound for the space of an inch. The nerve was thickened to twice its natural diameter at the place of injury. On dividing the fibres on the posterior part of the wounded nerve 'there was a small portion of the ball firmly imbedded in it which had been driven off by grazing the bone.'[39] How was it that tetanus did not occur in this instance, if something else beyond the mere irritation of the nerve by the presence of a foreign body were not required for its production? Dr. Mitchell, who had special and very extensive opportunities of studying the effects of gunshot lesions of nerves in the war of the Rebellion in the United States, has observed that 'the tendency towards irritation resulting in spasm, seems to increase

as the nerves divide and approach the skin.' He expresses his conviction that 'in the mass of tetanic histories the casual irritation has arisen in the extreme distribution of nerves, and where there has been no proof of previous injury to large trunks;' and, as evidence in favour of this statement, he mentions that there was not a single case of tetanus among two hundred instances of wounds of great nerves which had passed under his observation during the war.[10] This testimony bears very strongly against the notion of gunshot wounds of nerves being the chief cause of tetanus in time of war unless they are combined with other special conditions.

Effects of climate and atmospheric changes.—It is generally believed that tetanus occurs in a larger proportion among the wounded after actions in tropical climates than happens in more temperate latitudes; and that exposure to chills caused by damp night air, such as is often met with in succession to the elevated day temperature of hot countries, has an especial effect in producing it. Baron Larrey remarked among the wounded of the French army in Egypt that gunshot wounds in the course of nerves and wounds of joints were frequently followed by tetanus when the weather passed from one extreme to another, especially in marshy situations such as those adjacent to the Nile; while, when the temperature of the air remained equable, its appearance was rare. He made the same observation with regard to the occurrence of tetanus during the Austrian Campaign of 1809. The wounded who were the most exposed to the impression of cold and damp during the frosty nights of spring, after having been subjected to a very high temperature during the day, were nearly all attacked by tetanus. It only prevailed at that season.[11] He also noticed that the disease was more intense and more resembled hydrophobia in Egypt than as it appeared in the subsequent campaigns in the cooler climate of Austria.[12] In the United States' General Report on the materials available for a surgical history of the war, published in 1865, it was remarked that 'The records abound with illustrations of the influence of sudden vicissitudes of temperature in producing this fatal affection (tetanus), and of the effect which unextracted balls and other foreign bodies, and matter confined under fasciæ, appear to exercise upon its development.'[13] Tetanus is stated by Dr. Reeb to have prevailed at one time at Strasbourg during the siege in 1870, and he remarks that its appearance coincided in a remarkable manner with the depression of temperature and rains at the beginning of September. Médecin Principal Dr. D'Expers has also recorded, with regard to the occurrence of tetanus at Metz during the war, that the cold, which made itself felt especially at night, caused a sort of epidemic of tetanus, and that it then carried off many of the wounded, both those who had been operated upon and others, with great rapidity.[14]

Dr. Hammond, who directed the medical department of the army in the United States at the first part of the war, has since written: 'It was not uncommon, during the recent war, for the number of cases of tetanus to be very much increased immediately after a sudden change of the weather from dry to wet and cold.'[45] All accounts, indeed, agree in attributing a special influence to alternations from high to low degrees of temperature in the production of this complication, especially when these are joined with a damp atmosphere. Want of proper food, deficient clothing, and moral and physical depression are sometimes cited as predisposing causes of tetanus among wounded men. But they certainly are not alone efficient causes of its production among them. These conditions probably never existed in a more marked degree, consistently with the maintenance of an army at all, than they did in the English and Russian armies in the Crimea during part of the winter of 1854–55; yet tetanus, as already shown, was almost unknown at that period.

Effect of irritation of wounds by local disturbance.—Among the various other causes to which the occurrence of tetanus has been attributed have been the jolting and disturbance of wounds caused by the conveyance of patients in ill-constructed vehicles from the front to the field and other hospitals in the rear; but that this cause has ever exerted much influence, at any rate in temperate climates, seems very doubtful. There has been no lack of such rough conveyance of wounded in recent European wars; yet tetanus has certainly not been a prevailing disease in them.

That excessive irritation of gunshot wounds, when they are in an inflamed condition, before suppurative action has commenced, may act as an exciting cause of tetanus in tropical climates seems to be very probable. My attention was first attracted to this circumstance by my colleague, Professor Maclean. His observations in China had caused him to come to the conclusion that interference with inflamed wounds for the removal of lodged projectiles (and owing to the inferiority of the weapons employed by the Chinese, the bad quality of powder, and ill-formed bullets, most of them, when they penetrated, did lodge) was a fertile source of tetanus. As the observation is one of practical importance, I asked him to give me a note on the subject. The following is the memorandum with which he kindly furnished me:—

'The only cases of tetanus during the 1840–42 war in China following gunshot wounds resulted from the well-meant but injudicious efforts of inexperienced young medical officers to extract lodged missiles from the wounds of soldiers, after inflammatory action had set in, and before suppuration was established. I cannot recall the exact number of cases in which this untoward event occurred, but there were certainly not less than six, with, in every instance, a fatal result. The practice was put a stop to, and I did

not hear of another case afterwards. The wounds, in the examples mentioned, were received before Canton, and the treatment, followed by the consequences mentioned, was carried out on the passage down the river in the course of the two following days.'

At the time these cases occurred the solar rays were very powerful in the daytime, but the nights were cool, especially on the river. It may be a question how far these changes of temperature may have favoured the development of the disease which followed the untimely interference with the wounds just mentioned.

Causes of tetanus in armies reviewed.—A reconsideration of all the circumstances under which traumatic tetanus has occurred in military hospitals seems to point to the fact that several causes have generally acted in combination in the production of the disease. In addition to the local sources of irritation from the wounds themselves and its primary complications, there has probably been a special susceptibility on the part of the patients to the affection; while, further, certain extrinsic agencies have acted on the surfaces of their bodies, especially great alternations of temperature with strong currents of damp air. When tetanus has attacked wounded patients in a considerable proportion, the personal susceptibility of the subjects of the disease seems to have been induced or developed by nosocomial influences: particularly by an unsanitary condition of the atmosphere in which the wounded men have been placed. It is a noticeable fact that wherever tetanus is recorded to have prevailed to a really epidemic extent in military hospitals, the presence of other diseases indicative of an insalubrious state of them is mentioned also. At the different periods when tetanus existed as a common affection in the Peninsular hospitals, it appears from Sir J. McGrigor's report that contagious typhus, hospital gangrene, dysentery, and other allied diseases were also present in an aggravated degree.

Course followed by tetanus in gunshot wounds.—Tetanus sometimes occurs as a complication of gunshot wounds in quite an unexpected and sudden manner, speedily assuming its severest forms of manifestation; while, in other cases, both its invasion and progress are comparatively gradual and slow. The sudden and intense forms of tetanus more particularly belong to hot climates. They do not seem to have been met with in any large proportion among the cases which have occurred during modern wars in Europe. As observed by surgeons, in recent years, the attack of tetanus has been not unfrequently preceded by some general indications of constitutional disturbance, as loss of appetite, uneasiness, and mental depression. Some fresh pain, or more stiffness, about the wound has been noted in some cases. But when these premonitory symptoms have occurred, there has been nothing special about them to indicate the serious disease of which they were the

forerunners. The first indications that usually attract the notice and excite the suspicions of the surgeon as to their cause, are either spasmodic contractions near the seat of injury, or, what has happened more frequently, stiffness about the jaw or neck, which the patient at the onset has probably attributed to cold or rheumatism. With this latter symptom there is generally some difficulty in mastication and swallowing. These symptoms become more and more marked, while those of diaphragmatic spasm, with great pain at the scrobiculus cordis, are next added. The tetanic spasms extend to the muscles of the body and the extremities, especially the lower extremities, varying in intensity in different parts according to circumstances. The rigidity becomes greater, so much so that the jaw becomes completely '*locked*,' and the spasms recur at more frequent intervals, as the disease advances. The muscles of the arms are usually the last seized, unless the wound has been in one of the upper extremities, when the muscular contractions appear more early in them. The muscles which have become affected, hardly ever, if ever, become loosened into a state of complete relaxation; but, while still contracted, they pass into sudden uncontrollable paroxysms of still more violent contraction. These aggravated spasms are attended by pain of the most severe character. Sleeplessness is a general concomitant of the disease. Death sometimes follows an attack of violent spasm, or results from exhaustion, or according to Mr. Poland, more frequently occurs during an attack of asphyxia and suffocation from spasm of the muscles of respiration.

Period of its occurrence.—The time at which a gunshot wound may be followed by tetanus seems to be quite uncertain. It may follow the wound quickly, or many days may elapse before it appears. By some this interval has been spoken of as a period of incubation; but the length of time which passes before the attack occurs may well depend upon accidental circumstances, as much as the attack itself. There is a prevailing belief that the more speedily tetanus occurs after a wound the more certain is it to terminate fatally; while the more prolonged the period, the more chance is there of recovery. Mr. Poland, in illustration of this point, has mentioned that of 227 collected cases of tetanus, 130 occurred previous to the 10th day after the injury, and of these 101 died; 126 cases from the 10th to the 22nd day, and of these 65 died; 21 cases above 22 days, and of these 8 died.[46] These observations overthrow the conclusion which Sir J. McGrigor mentions the Peninsular surgeons had come to—that if tetanus does not occur for 22 days from the date of the wound the patient is safe. The following case, the particulars of which were given to me by Surgeon Applin of the Royal Artillery, would seem to show that tetanus may be induced by a wound, and not manifest itself until some months after its occurrence, and even long after the wound

has healed. The subject of it was a younger brother of Dr. Applin. His gun exploded while he was out shooting, and the top of his left thumb was carried away. Amputation was performed, and, on the wound becoming healed, he returned to his studies. Nearly four months afterwards trismus suddenly appeared, and he expired on the following day during a severe fit of opisthotonos. This case somewhat resembles one of a patient in Guy's Hospital related by Mr. Morgan. A sailor had a lacerated wound of the thumb. It had been transfixed by a piece of teak wood. The wound healed perfectly. About two months afterwards a painful neuralgic affection of the muscles of the thumb came on; tetanus followed, and he died. On dissection two small splinters were found in the abductor muscle against a branch of the radial nerve.

Cause of the general immunity from tetanus in the Crimean war. To what circumstances are we to attribute the comparative immunity from tetanus which the wounded of the Crimean armies, English, French, and Russians, enjoyed? Certainly the contrast between the number of cases which were met with during the Crimean war, and the number of those which occurred in previous wars, is very remarkable. I am inclined to attribute the absence of tetanus from the field hospitals principally to the following circumstances: the free circulation of fresh air from the sea over the elevated and well-drained plateau on which the armies were encamped; the fact that the wounded were treated in separate tents or huts; and, probably also, to a generally simpler treatment of the wounds themselves than was formerly in vogue. But the active circulation of pure, and, at most seasons, comparatively dry air, was probably the most efficient preventive of the disease. Improved hygienic arrangements with wider separation of beds, allotment of more cubical space, and greater purity of surrounding air, have undoubtedly largely contributed to the diminution of tetanus in recent wars; as they have done also to the prevention of hospital gangrene, and other allied diseases. The condition of the general hospitals during the early campaigns of the present century has been very strongly animadverted upon by distinguished surgeons. So in Lucknow the prevalence of tetanus may be in a great measure explained by the circumstances of the troops—hemmed in as they were by the enemy, overworked, and subjected to all kinds of depressing influences, mental and bodily, in a tropical climate; while the hospitals were not only unavoidably placed under the most unsanitary surrounding conditions, but had become internally infected by the emanations of the many wounded who were successively and without intermission placed in them. The comparative rarity of tetanus among the wounded in modern naval engagements has, no doubt, also been due to the greater attention which has been given to hygienic arrangements, since their importance has been better understood by those in authority. Dr. Dickson, Physician

to the Fleet, who read a paper before the Medico-Chirurgical Society upon tetanus, which he had the opportunity of observing among some soldiers from the expedition against New Orleans in 1815, when referring to the diminution in the proportionate number of cases after wounds in the engagements of that period on the West India station as compared with the proportions in previous wars in the same climate, was led to attribute this difference to improved hygienic circumstances among other causes. He concluded his remarks by the following summary: 'I trust I am therefore justified in inferring that to the improvements in the medical and surgical treatment of wounds; in cleanliness and ventilation, avoiding at the same time exposure to currents of cold air, or sudden changes of temperature; in fine, to superior comforts, diet, and accommodation; and particularly to the greater attention paid to the state of the bowels, may be attributed the great infrequency of tetanus of late in the West Indies, when compared with former wars.'[47] The superior comforts, diet, and treatment would have hardly had much influence in lessening the tetanus, without the better ventilation and greater cleanliness mentioned by Dr. Dickson; for, destitute of good accommodation, good diet, and comforts, as the troops in the Crimea were at certain periods, there was no prevalence of tetanus then, and such cases of tetanus as did occur among the wounded took place at the time when the troops, and the wounded among them, had everything that could be desired in these respects.

Tetanus in its acute and chronic forms.—Larrey, in his first memoir on tetanus,[48] has divided the disease into acute and chronic tetanus, and the division seems a practically useful one. There is probably no essential difference in nature between the one and the other. The acceleration and severity of the symptoms in the one case, and their relatively slow progression and mildness in the other, appear only to be indicative of a more or less powerful exciting cause, and a more or less susceptible state on the part of the patient. But repeated observation has shown that when the intense symptoms occur which characterise the disease in its acute form, it is almost without exception fatal; while, when it assumes the more mitigated chronic form, a certain proportion of cases, though only a small one, become amenable to treatment and recover. Hennen, whose opportunities of observing the disease were very extensive, owing to his having had charge of some of the most important surgical hospitals in the Peninsula between 1811 and 1814, and of the large Jesuits' Hospital at Brussels after the battle of Waterloo, wrote: 'I have never been fortunate enough to cure a case of acute tetanus; in some instances of the chronic species I have effected or witnessed relief.[49] Out of the 363 cases of tetanus during the United States War 336 cases terminated fatally. The disease was of a chronic form in 23 out of 27 recoveries, in the

remaining 4 cases the symptoms are described as having been very grave.

Pathology of tetanus after wounds.—In those cases of tetanus after gunshot wounds, where there has been sufficient evidence of injury to important nerves having been the proximate local cause of the attacks, some particular action, resulting from the irritation which had been set up, must have proceeded from the seat of injury, along the sensory nerves and their communicating fibres in the spinal cord, to the roots of the motor nerves, and so onwards to the muscles to which these nerves were distributed. What this action along the nerves is, or what change is induced in the condition of the ganglionic portions of the motor tracks by the continued irritation thus carried to them and extending itself along the substance of the cord, has not as yet been made clear; although it is evident, from the diffused tetanic action which spreads, more or less quickly, over the whole frame in well-marked cases, that some morbid condition must be established in them. As long ago as the year 1854 my colleague, Professor Aitken, discovered, from post-mortem examination of certain cases of tetanus after wounds, that an increase in the specific gravity of the cord substance accompanies this complication; and further, that the change in specific gravity occurs abruptly about that region of the cord which is in direct communication with the part of the body in which the wound has been inflicted.[50] Other observers have described inflammatory appearances in the spinal cord and medulla oblongata; while Mr. Lockhart Clarke has pointed out that, in certain cases of tetanus, extensive lesions of structure of different kinds are to be noticed, such as disintegration and softening of portions of the grey substance of the cord.[51] But the pathology of tetanus is confessedly still by no means satisfactorily understood.

CHAPTER VIII.

ERYSIPELAS AFTER GUNSHOT WOUNDS.

The occurrence of erysipelatous inflammation in a gunshot wound is a complication much dreaded by surgeons of military hospitals; not only on account of its direct effects on the particular patients attacked by it, but also on account of its liability to spread and attack other wounds of a similar nature, and the difficulty which is often met with in eradicating it from a hospital when circumstances do not permit the hospital to be emptied of patients and thoroughly disinfected.

Wounds specially susceptible to erysipelas.—Gunshot wounds are liable at all times to be attended by erysipelas, but they do not

exhibit the same susceptibility to this disease in their early stages that they do at later periods. As happens in contused wounds from other causes, so, in those produced by gunshot, wounds of the head and face appear to be especially susceptible to its influence. Patients suffering from wounds of the limbs with fracture of the shafts of bones, or with carious cavities in their articular extremities, when they have been long under treatment, and especially when the wounds are subjected to a source of irritation such as arises from the presence of sharp sequestra, seem also particularly prone to be attacked by erysipelas. Owing to the preponderance of cases of wounds of the extremities, and especially of wounds of the lower extremities, among those which remain a long time under treatment in military hospitals, it is more particularly in connection with these injuries that the occurrence of erysipelas has been noticed.

Causes of erysipelas.—Erysipelas in some instances appears to arise spontaneously, or at least to be generated by a congress of conditions favourable to its birth and development; but very frequently, especially in those cases in which the complication is presented in its most severe form, there is every reason to believe that it is either imported from without, or is communicated by infection or contagion. In the majority of the cases which appear to owe their origin to specific communication there may be traced either a predisposing condition in the depressed state of constitution of the patient, or in the condition of the wound, or favouring circumstances in the locality and in the state of the atmosphere in which the patient is placed, and it becomes difficult to determine how much the occurrence of the complication is due to these circumstances and how much to contagion; but other instances occur in which a wound is attacked by erysipelas where no such predisposition can be discovered, the subject of which is apparently in a good state of health, when the dressings which have been employed have been of the simplest and least irritating character, and where nothing unsanitary can be detected in the surroundings of the patient. Under such circumstances the only explanation of its occurrence seems to be the direct contact and influence of a specific virus. What the nature of the specific matter is by which erysipelas is caused to spread from one patient to another is quite unknown, but the communication and extension of the disease has been so frequently observed in hospitals that no doubt regarding its contagious nature can be reasonably entertained.

Influence of depressed vital energy.—That depressed vital force in patients suffering from gunshot wounds will not of itself suffice for the production of erysipelas was sufficiently proved during the Crimean War. Never, perhaps, have troops been employed on active service in whom vital energy was more reduced than it was among that portion of the Crimean army whose fate it was, after passing some months in the pestiferous valleys of Bulgaria, to be

stationed on the heights before Sebastopol, during the winter of 1854–55. After being subjected to a long-continued visitation of cholera and choleraic diarrhœa, the officers and men who were stationed on the Crimean heights had for a time to undergo the further depressing influence of exposure to severe cold, continued damp, deficient shelter and clothing, a spare unvaried diet of innutritious and imperfectly cooked food, with harassing duties, until at last every survivor remaining on the plateau exhibited the most marked features of cachectic debility; yet erysipelas was not one of the diseases to which the patients under treatment for gunshot wounds fell victims. I did not myself see a single case of erysipelas during that fatal period, and the hospital returns in general show that it was not one of the complications of wounds or causes of death among them. Certain ingredients in the production of the disease were wanting: it was not introduced from without, nor was there the impure atmosphere to generate it within. During that trying winter the troops were under canvas for the most part old and threadbare, and the free movement of air over the somewhat elevated and bare peninsular plateau sufficiently prevented either atmospheric stagnation or impurity in the camp. When, subsequently, the tent hospitals were replaced by hut hospitals, the majority of those who had passed through the period of depression, had succumbed to other diseases or had been sent away as invalids; while, with the huts, came improved circumstances in all respects. Had erysipelas been introduced to any of the hospitals among the wounded at the time when the anæmic and scorbutic condition was universally prevalent, there is no reason to doubt that it would have spread with rapidity among them, and have assumed a virulent and fatal character.

On the other hand, a generally healthy and vigorous state of constitution, and good hygienic arrangements, will not serve as a sufficient protection against the ingraftment of erysipelas, if it be introduced among men suffering from wounds. Erysipelas has appeared on several occasions at Netley, but the measures taken have always succeeded in preventing it from spreading beyond a very limited number of patients. In each instance there has seemed to be sufficient evidence to warrant the conclusion that it had been introduced from without by patients who had previously had the disease elsewhere. On the last occasion, in 1874, it appeared among some patients in the hospital, who had been wounded during the expedition on the Gold Coast. In each instance in which this complication ensued, there was gunshot injury to bone, and all the wounds were in a suppurating condition.

Site of wound attacked.—The gravity of an attack of erysipelas depends not only on the state of health and power of constitution of a patient, but also on the situation of the wound which may be regarded as a predisposing cause of its invasion. Thus, wounds

about the neck attacked by erysipelas are especially dangerous, from the risk of the larynx becoming implicated in the inflammatory action, inducing œdema of the glottis; wounds about the head, from the risk of meningeal and cerebral complications; while its appearance in wounds of the extremities, its most common situation, in its simple form is not only unattended by such hazardous complications, but is also, as a rule, unaccompanied with the amount of constitutional disturbance and fever, which are met with when the disease attacks wounds of the head or neck. When erysipelas invades a wound of one of the extremities, especially of the lower extremity, and is complicated by diffuse inflammation of the subcutaneous structures, the symptoms which then accompany it are apt to assume a very aggravated character, and are often followed by such grave results that the patient's life is placed in a condition of much danger by them.

Early symptoms.—The occurrence of erysipelas rarely takes place in a patient without some symptoms of constitutional or visceral disturbance being exhibited previously. There is usually a failure of appetite, constipation, or some other indications of want of regularity in the digestive functions, for one or two days before the attack. The patient awakes with headache, or complains of not feeling so well as he has been feeling, without being able to define any particular ailment, or states that he has not slept so well, that he has been restless and fidgety, and that he has felt drowsy, or wearied, or chilly. Perhaps he has an attack of rigors, which, if he is a subject of malarial poisoning, he believes to be the onset of an attack of ague. The temperature rises, the pulse increases in frequency, and the other usual indications of a state of pyrexial disturbance are present. As these symptoms are noticed, the wound loses its healthy character, and the disease soon makes itself manifest. The premonitory symptoms which have been just mentioned, may, however, be so slight as not to be observed, or they may be absent altogether, and the local evidence at the situation of the wound may give the first indications that erysipelas has set in.

Course taken by simple erysipelas in gunshot wounds.—There is no peculiarity in the manner in which erysipelas attacks a gunshot wound, nor in the phenomena by which it is made manifest. The skin is found to be of a bright pink colour, shining, and hot to the touch; for some distance round the wound, it feels hot and tingling, or smarting to the patient; the edges of the wound are swollen and probably somewhat everted; granulations appear pale and œdematous; the discharges from the wound are thin, serous, scanty, or almost entirely suppressed; there is a marked contrast between the colour of the inflamed and adjoining healthy skin, but no defined rigid boundary can be felt between them as in a phlegmonous inflammation; the erysipelatous redness has a tendency to extend

itself; on pressure by the finger the redness fades away, but it quickly returns when the finger is removed. The inflammation, if mild in form, may be confined to the skin, and it may be difficult to distinguish it from ordinary erythema; or it may involve the subcuticular areolar tissue, and be accompanied with increased swelling in consequence, which will probably extend to a considerable distance from the seat of injury. In the former case the inflammation may gradually disappear after a few days, its disappearance being followed simply by desquamation of cuticle: in the latter case, the inflammation will be of longer duration, and may be followed by the formation of small abscesses at different points beneath the inflamed surface.

Phlegmonous erysipelas.—But the erysipelas may assume a far more formidable form than either of these above-mentioned. The deeper structures may become so involved in the inflammatory action, and the inflammation may be so severe in its character, that not only diffuse suppuration but mortification of some of the structures may result. This is the form which is usually designated 'phlegmonous erysipelas,' while the milder varieties are spoken of as 'simple erysipelas.' Parts, which conveyed to the finger on pressure a hard firm character, become soft and boggy. If the skin ulcerates or sloughs, or is opened, it is observed to be undermined, while fœtid pus mixed with dead connective tissue is found diffused beneath it. In patients who have become greatly debilitated the erysipelas may extend so far from the seat of injury where it commenced, and such great destruction of tissues may take place in the manner described, that the patient's powers become taxed beyond endurance, and a fatal termination ensues.

CHAPTER IX.

TRAUMATIC DELIRIUM AFTER GUNSHOT WOUNDS.

The delirious excitement which is occasionally met with in subjects of gunshot wounds is a complication which always causes much trouble and anxiety to military surgeons when it occurs. It differs in certain particulars from ordinary delirium tremens, although, in some instances, the excessive susceptibility of the patient's nervous system may be due to the habitual use of alcoholic drinks prior to the infliction of the gunshot injury which has led to the excitement; or, if the use of intoxicating liquors be not habitual, then to excessive indulgence in them just before, or at the time of the injury. The excessive use of strong tobacco has been supposed to have had a similar effect in the production of nervous excitement after exhausting wounds. In other cases, however, no

such direct influences as these exist, and the occurrence of the complication is manifestly due to an irritable state of the nervous system, brought about sometimes by constitutional, sometimes by mental causes, but always associated with depressed vital power. The exact nature of the patient's state cannot be defined, but it is one which renders his nervous system specially susceptible to disturbance, and liable to exhibit the effects of this disturbance under the form of excitement and delirium, when a part of his frame is subjected to sudden violent injury.

Temporary excitement after gunshot wounds.—Whenever a gunshot injury is attended with general shock, more or less disturbance of the cerebral functions is one of the usual phenomena exhibited. Consciousness may be entirely lost for a time, or, in addition to a certain amount of interference with general power of motion and sensation, there is mental confusion and bewilderment, varying in degree in different individuals. In occasional instances, a person after having been shot becomes the subject of insane excitement, talks incoherently, loses consciousness of the scene and circumstances around him, and shows by his manner and expressions that he has ceased to be able to control his thoughts and actions. In soldiers' language, 'the shot has turned his brain.' In some instances this excitement simply shows itself in unrestrained exaggeration of language and conduct, in others in violent rage against the enemy, in others in convulsive weeping of a hysterical character; such manifestations being often quite foreign to the natural dispositions or ordinary habits of the patients concerned. The condition is probably traceable to the conflicting emotions aroused by the consciousness of a sudden injury in persons who are already in an over-wrought state of mind—in men who have been stirred up into a storm of passionate excitement by the clamour and thrilling incidents of the struggle in which they have been engaged. It varies in duration, as it does in degree, in different individuals, but it rarely lasts long, and not unfrequently ends in a state of languor and inertness as noticeable as the previous state of exaltation.

Nature and symptoms of true traumatic delirium.—This is not, however, what is understood by the complication under notice. To warrant the name of 'traumatic delirium' something more is needed than that condition of temporary excitement, or disturbance of the intellectual faculties, produced by the direct effects of physical commotion, or by excessive mental agitation, on the receipt of a gunshot injury. There is frequently no sign of it in the early condition of the patient, which may be one simply of shock with general depression and without any marked intellectual disturbance at all. In a day or two after the injury the mind, which up to that time had been calm and collected, begins to wander; a condition of nervous excitement is shown by the intense expression

and alertness of the patient's eyes; the patient becomes the subject of delusions, generally of an agitating and alarming character; he becomes more and more restless, and has an anxious expression of face; the wound does not attract his attention; if it be accompanied with pain, it is not complained of, and appears not to be felt, for, if not restrained, the patient will sometimes aggravate the injury already existing to an extent which must in itself be productive of increased pain; all circumstances which act on the nerves of sight and hearing—such as the movements about him of attendants, strong light, noises of all kinds, especially abrupt and loud noises—add to the agitation of the patient; the surface of his body is moist, the perspiration perhaps being even profuse; the pulse is excited, not full and bounding as in inflammatory fever, but rather weak and compressible.

The mental condition of the patient is often as curious as it is painful to witness. He appears to be dreaming, and taking an active part in some exciting and distressing dream, although he is in a state of full wakefulness. Everything around him adapts itself to the train of thought which forms the subject of the dream, just as occurs in the dreams of sleepers. Even such realities as his wound, and the pain caused by it, cease to be recognised, or are made to chime in with the general subject of his thoughts. In this early part of the attack the patient may be temporarily recalled to a state of normal consciousness by the surgeon, so far as complying with simple directions that may be given to him; but as the nervous excitement becomes intensified in the progress of the case, even this power of arousing the patient to a sense of realities about him ceases. The patient becomes completely the victim of his delusions, so that he cannot be diverted from them even for a moment, or be made to appreciate intelligently any words that may be addressed to him.

This condition of excitement without repose, if long continued, will eventually exhaust the patient, and induce a fatal termination of the case; if, on the other hand, remedies produce the desired effects, the excitement may be lessened by degrees, sleep be obtained, a condition of nervous and mental tranquillity be gradually restored, and the patient completely recover.

Traumatic delirium and delirium tremens.—The difference between traumatic delirium and delirium tremens induced by excessive alcoholic drinking is chiefly marked by the absence of that trembling condition of the limbs which has given the name to the latter disease. Agitated as the arms of the patient suffering from traumatic delirium may be, and constant as their movements may be, there is no apparent want of general muscular firmness in them. The effort which is made to reach or remove some imaginary object is made as it would be made under like circumstances if they were real; it is not marked by those secondary tremulous

motions which constantly accompany the general movements of persons affected with delirium tremens. At the same time there is undoubtedly close analogy between the two diseases, though the causes which induce them may be different. The same state of constitutional depression, with excessive nervous irritability and excitement, exists in both diseases. The liability to dangerous nervous excitement and delirium when surgical operations have to be performed on persons habituated to the use of intoxicating drinks, or when persons in a state of drunkenness meet with grave injuries, and the increased mortality in such cases, are familiar to all surgeons. The traumatic delirium which then ensues has all the characteristic features of delirium tremens.

Special causes with troops on active service.—Traumatic delirium in field practice is usually met with in soldiers who have become lowered in constitutional tone by disproportionate fatigue, most especially such as arises from excessive night duties with the interrupted and limited amount of sleep, and the forced strain on the attention, which they entail, but also by that which results from long and harassing marches, irregular meals, exposure to inclement weather, and other depressing circumstances incidental to field service, which have been before mentioned. Under these conditions, but more particularly those of broken rest and watching of a responsible and often anxious character, not only is the constitutional vigour lessened, but an abnormal irritability of the nervous system is engendered. The depressed and irritable condition thus induced will be aggravated by loss of blood, shock, and pain, incidental to a gunshot wound. If a man wounded under such circumstances have been recently indulging in the use of stimulants, the depression will be all the lower, and the less will he be able to bear up against the additional strain which the gunshot injury entails on his nervous system. One of the most distressing and rapidly fatal cases of traumatic delirium I ever saw occurred in an officer, who received a very severe wound at a time when deprivation of sleep and a certain amount of over-stimulation by alcoholic liquor had combined to place him in a state of much nervous exhaustion. Captain K——, a tall, powerful officer, who had served in the field from the time the army landed in the Crimea, was kept constantly on the alert by the enemy while on piquet duty during the night of the 4th of November, 1854, and had just returned to camp, very tired and exhausted, when he was again ordered to the front. The battle of Inkerman had commenced on the right front of the position. Captain K— — had filled his pocket flask with some spirit the evening before when going on duty, and had drunk this in the course of the night. He had only time to take a cup of coffee which his servant had poured out for him, and into which he poured a little rum to arouse his flagged energy, before moving off with his party toward the front. He had not been long away when a heavy round shot

struck him on the left knee, smashing the joint, and leaving the leg hanging only by skin and shreds of contused tissues. I had to amputate the limb at the lower third of the thigh. Scarcely any blood was lost at the operation, and very little bleeding had occurred at the time the wound was received. He rallied satisfactorily from the shock of the injury and succeeding operation, was very easy and comfortable throughout the day, and no symptom indicative of approaching danger showed itself. He, however, got no sleep that day, and only very partial and disturbed sleep during the following night. The next day traumatic delirium set in, and at last assumed a character of most violent excitement with distressing hallucinations, leading to the necessity not only of close watching, but also of restraint by two attendants to prevent him from injuring himself. The delirium continued during the succeeding night, and eventually, on the morning of the third day (the second after that on which the wound was received) extreme exhaustion and coma terminated the sufferings of the patient.

At the time when it was necessary to remove wounded men, or men upon whom operations, such as amputations, had been performed a few days before, from the front to the port of Balaclava for passage to Scutari, the additional exhaustion resulting from the disturbance and fatigue of the journey in not a few cases caused the men on their arrival at Balaclava to be in a state of delirium. Rest, nourishment, and appropriate remedies, in most instances, restored the patients; but, at one period of the war, so great was the prevailing prostration, and so seriously exhausting was the journey to Balaclava, which had to be performed by the patients sitting upright on led cavalry horses (the only means by which it could be accomplished for some time during the first winter), that in many cases the excitement thus produced was only the prelude to a quickly fatal termination.

Effect of discharges of ordnance, and of panic, among wounded soldiers.—Another fertile source of traumatic delirium is met with in time of war when wounded men, or men who have suffered amputation, are subjected to intense mental agitation from an overwhelming sense of danger which they are conscious they can do little of themselves to avert. The agitating effects of the startling loud reports, and the sudden violent concussions produced by discharges of artillery predispose to the occurrence of the disease by keeping the wounded patients constantly on the alert and by breaking sleep. Even persons in full strength and health are frequently bewildered and upset by the commotion resulting from repeated discharges of ordnance; and it can readily be imagined that to men reduced in nervous tone by grave injuries, by loss of blood, and previous constitutional degradation from any cause, the agitation from such sources of disturbance as those above-mentioned must often be intense and well calculated to overthrow intellectual

equilibrium altogether. These causes of traumatic delirium appear to have exerted a marked influence in some of the places besieged by the Germans during the Franco-German War of 1870–71. The remarks of two surgeons, Dr. Poncet and Dr. Reeb, on the prevalence of traumatic delirium in the military hospital during the siege of Strasbourg, are quoted by Dr. Chenu in his surgical history of the war.[52] Dr. Poncet shows very forcibly the influence of mental alarm in the production of this complication. 'Nervous delirium has played such an important part,' he writes, 'in all the gunshot wounds, that one might well have believed, at certain times, that a veritable epidemic of it was prevailing. From the 25th to the 30th September nearly the whole of the wounded under our care, about 150, presented these nervous symptoms; one would have said the wards were filled with madmen. During the night of the 19th of September, the arsenal, which was only separated from our wards by the narrow Vauban canal, was destroyed by the fire of the enemy. At midnight, a rain of sparks and flakes of fire covered the hospital; the brightness of the conflagration illumined the beds of the patients more vividly than at noonday; a favourable wind, and we had been enveloped in the flames. Numerous shells burst over the arsenal, keeping up the fire, killing and wounding those who carried assistance, and even penetrating to the centre of the hospital, and reaching some of the sick, who were incapable of moving. A panic seized the wounded in spite of all assurances that assistance was organised and certain in case of need. Our amputated patients got up from their beds, men with fractured limbs disturbed the apparatus which had been applied to them—delirium became general. Some, victims of hallucinations, threatened the enemy; others, on the contrary, seemingly calm, followed with an unquiet and terrified look the progress of the fire or the path of the shells. The day following, when all immediate danger was removed, delirium broke out among those who had been the most calm during the previous night, and these cerebral disturbances were followed by general gangrene of stumps and ragged flaps of wounds, the initial rigors of pyæmia, and sudden deaths. It was on the 28th of September and following days that we had the greatest mortality.' Dr. Reeb particularly dwells on the pernicious results of the deteriorated atmosphere in which the patients were placed through agglomeration in one and the same building, and he evidently regarded the bad influence exerted by this cause as an important element in the development of nervous delirium among the patients. He remarks on the different results which he had witnessed in Algeria, where wounds and amputations healed readily, in spite of unfavourable conditions of transport, accommodation, and nourishment, owing to the purity of the atmosphere which surrounded the patients. Dr. Reeb points out that it was at the period when infectious maladies due to the local unhygienic con-

ditions were most rife at the Strasbourg military hospital-that cases of acute delirium declared themselves in the greatest number among the wounded. At the same time he fully admitted that the continual cannonade, the prolonged wakefulness, the alarms from shells falling on the building, and from the threatening aspects of fires in the neighbourhood, contributed directly to its development.

It may be here remarked that it is always most difficult, under ordinary circumstances, indeed, impracticable, to comply with hygienic requirements in the treatment of wounded men in fortified towns and strongholds when they are in a state of siege, though the evils arising from hygienic difficulties may be lessened to a certain extent by an intelligent appreciation of them. The most urgent and most obvious necessity is to place the wounded where they will be least exposed to additional dangers from the projectiles of the besiegers. Hence the use of buildings as thickly covered and as strongly enclosed as possible, even cellars, for hospital purposes; and hence, also, in any place thought specially secure, an overcrowding fraught with the most deleterious consequences as regards the development of the various complications of wounds which have just been under notice. The difficulties in the way of surgeons, whatever efforts they may make to ward off these complications, are almost insuperable under such conditions.

Under all the circumstances which have been mentioned the coexistence of depressed vital power in the wounded patient on the one hand, and proportionally excessive nervous excitement on the other, may be observed constantly to concur in the production of the complication of traumatic delirium just discussed.

SECTION VII.

ON THE ULTERIOR CONSEQUENCES AND DISABLING EFFECTS OF GUNSHOT INJURIES.

General remarks.—The subjects of gunshot wounds are often said to have recovered from their injuries when all that has been accomplished is that the wounds have become cicatrised; no reference being made in the remark to the consequences which have resulted from them. But gunshot wounds very frequently leave behind them ill consequences, often of a very grave character, after the lesions directly produced by the projectiles, or the surgical operations which the lesions have led to, have become entirely healed. Wounded soldiers are incapacitated for service in a very large proportion by the effects of their wounds, although the wounds themselves have become sound. Some of these results are complete and permanent in character as soon as cicatrisation has taken place, as when a gunshot injury has necessitated amputation of a limb; others, on the other hand, remain incomplete for long periods after the healing process of the wound has been accomplished. Alterations occur, in some instances, as years go on, of such a nature as to diminish the disabling effects of the sequelæ left by the wounds; in other instances, the sequelæ lead to the development of morbid conditions which become sources of infirmity and suffering, or even induce fatal consequences at remote periods after the dates of the original injuries.

One of the most fertile sources of prolonged inconvenience, pain, and secondary disease, after gunshot wounds is the presence of foreign bodies which became lodged at the time the wounds were inflicted, and either from oversight, from the depth or particular situations to which they penetrated, or from some other difficulties in the way of their discovery or dislodgement, have remained unextracted. The remote effects of gunshot wounds from this source differ so very greatly with different circumstances, that it will be useful to consider the subject at some length.

When this complication has not occurred, the disabling effects and remote consequences of gunshot wounds vary with the anato-

mical structures involved in the original lesions, and the complications which attended them before the healing process was completed. The effects may be studied according as the lesions have occurred in particular tissues of the body: the skin, connective tissue, muscular and tendinous structures, or bone. Again, they may be considered with reference to the particular regions of the body in which the injuries have happened, in accordance with the classification elsewhere described. Many points connected with the remote consequences of gunshot wounds in these special regions can only be discussed at the time that the circumstances and treatment of the particular injuries themselves are taken into consideration, but their general features may be described in this place with advantage. The remote effects of unextracted foreign bodies will be first noticed.

CHAPTER I.

CONSEQUENCES OF LODGEMENT OF FOREIGN BODIES IN WOUNDS.

General effects very variable.—There is no feature in gunshot wounds more uncertain, nothing more difficult to prognosticate in any particular case, than the future effects of the continued lodgement of bullets and other metallic substances among the tissues of the body. In most instances lodged bullets cause more or less interference with some of the natural bodily movements, and give rise to pain which may last for life if they are not removed; but, in exceptional cases, they remain for long periods inert, and without causing any noticeable inconvenience. Sometimes they remain quietly in the place to which they have been originally carried; sometimes they wander away, travelling between muscles and tendons and around bones, until they reach some part where the inconvenience caused by their presence is intolerable, or till their further progress is arrested by some impediment, or until, under the influence of what Hunter has called the 'instinctive provision in parts to remove themselves so as to bring extraneous bodies to the skin for their exit,'[1] they reach some part of the surface of the body whence their extraction is accomplished with facility.

Effects on the cicatrisation of wounds.—The effects of the lodgement of foreign bodies during the early stages of gunshot wounds have been noticed when describing their primary complications. Occasionally under favourable circumstances a wound will become soundly healed notwithstanding a foreign body remains unextracted; but, more generally, its presence not merely delays but altogether prevents complete cicatrisation. The parts surrounding the site

of lodgement remain tumefied and tender. Constitutional febrile disturbance is excited, suppurative discharge continues from the original opening made by the projectile, while, without the greatest care and attention to ensure the escape of the discharges by this outlet, matter will accumulate, find its way in other directions, and give rise to deep and extensive abscesses. Sometimes the irritation from these conditions may be so intense as to lead to the gravest complications, unless the foreign body which is its source is detected and removed. At other times the irritation will gradually subside, and the wound will become healed, but only to reopen from time to time; while, in others again, complete closure will never take place, but the track of the projectile will become converted into a narrow sinus from which a serous oozing, varying from time to time in quantity, will continue for years.

The nature of the material lodged has less influence than its superficial qualities.—The degree of irritation caused by the presence of a foreign body seems to depend more upon its form and external qualities than upon its nature. Rounded metallic bodies, as a rule, induce a remarkably small amount of irritation in the living tissues. If the foreign body be metallic and have a generally smooth surface, and be within certain limits of size, it matters not of what metal it consists. Lead, tin, iron, copper, and brass may be retained in certain situations in the body with equal apparent impunity. Examples of leaden bullets lodging in parts of the body for many years, sometimes in delicate viscera, without being changed themselves and without causing irritation, have frequently occurred. In April 1859 an iron canister shot was removed from the supraspinous fossa of the right scapula of an invalid at Fort Pitt. The man had been wounded at Maharajpore, in 1843, but had only been inconvenienced by the presence of the shot a short time before its removal. Even sharp pointed bodies seem to be able to travel slowly through the body, without exciting a marked degree of irritation in their course, if their surfaces are smooth and polished. The fact is well established that steel needles, and other sharp pointed metallic articles, which have been swallowed, may move slowly to distant parts of the body without giving rise to pain, without interfering with the functions of the organs traversed, and without injury to blood-vessels or nerves, until they reach the neighbourhood of the skin, when for the first time they make known the fact of their lodgement by pain and the formation of an abscess. On being removed they are usually found in the same state as when they were swallowed. In a similar way after a gunshot wound the situation of a lodged foreign body will sometimes betray itself long after the time of its first lodgement by the appearance of a tumour in some situation, accompanied with signs of inflammation and suppuration. An abscess is diagnosed, and on being opened the foreign body is found within it.

My friend, Sir A. D. Home, removed a brass button from a soldier by whom the lodgement of this foreign body had never been suspected. The man had received a large number of wounds at the battle of Balaklava, and was taken prisoner by the Russians, but subsequently returned to his regiment. After having been some time at duty he complained of a hard and tender swelling on his chest near the right nipple. He had been wounded at Balaklava on the opposite side of the chest, near the left nipple, by a musket bullet. The projectile did not penetrate deeply, and was removed after the action without difficulty. Dr. Home, however, suspecting that some foreign body had been carried in by the bullet and was still lodging, cut down on the swelling on the right side, and there discovered a coat button. It was lying in a small encysted abscess, and retained its original bright surface. Up to a short time before the man made the complaint on the subject—a period of two years from the date of the original wound—the lodgement of this foreign body had not given the least indication of its presence. It was only after his return to military duty that the pressure of the man's belt set up the inflammation which led to its discovery.

The unchanged condition in which such foreign bodies are usually found after being extracted, is in all probability mainly due to the fact of their having been excluded from the access of the air; were they subjected to its influence while lying in the warm and moist tissues of the body, chemical changes would be induced which, in some of the metals, would certainly prevent them from remaining inert as now so frequently happens.

Similar freedom from irritation is rarely witnessed when the lodged foreign body is porous or cellular in its substance, and has an irregular outline, sharp edges, or a rough surface. Splinters of wood, spiculæ of bone detached and driven into neighbouring tissues by the force of a bullet, tufts of hair or wool, shreds of cloth or cotton garments, seldom permit a wound in which they remain imbedded to become soundly healed. The aperture of the wound may close up for a time, but, if there be no other way of escape for such foreign bodies, they invariably lead to the wound opening again. Pieces of woollen cloth in particular are observed to act as local irritants. Repeated experience shows that whatever time may elapse, so long as a fragment of cloth remains in any part of a wound made by a projectile, so long it will never become soundly healed. A fistulous track, and a certain amount of purulent discharge from its aperture, will usually be maintained during the whole period of its lodgement. It is surprising to find how small a piece of cloth, sometimes not more than a few fibres, will suffice to exert a noxious influence and to prevent the healing process from being perfected.

Dr. Neudorfer has attributed the deleterious action of such

substances to the fact of their being of an organic nature. He regards lodged foreign bodies as comparatively innocuous or noxious according as they belong to the inorganic or organic kingdom. His views are that all changeable and putrescible bodies, as fragments of bone, wood, cotton, linen, or woollen cloth, when lodged, enter into fermentation or decomposition under the favourable conditions of air, warmth, and moisture, in which they are placed, and then act as ferments on the easily decomposable constituents of the blood and humours of the tissues, and so lead to their disintegration. Such special importance does Dr. Neudörfer attribute to their decomposable nature, that, while he maintains their presence to be injurious in all parts of the body on account of it, he considers lodged organic substances to be so dangerous to life in certain situations, as in the lungs, owing to the multitude of vessels in them and their special function of respiration, that no efforts should be spared to effect their extraction at the earliest opportunity as a matter of vital necessity.[2]

Such an explanation hardly appears to be justified by observation. Pieces of woollen cloth, small coils of linen cloth, have lodged at the bottom of sinuous tracks of wounds for many years, without showing evidence of alteration.[3] Few substances are in their nature more durable, or less liable to be acted upon by the fluids among which they are placed when lodged in the tissues of the human body, than hairs, yet nothing will more persistently act as a source of irritation than they will, even a small number of them, under such circumstances. No wound, it is well known, will become soundly closed until they are removed. A fragment of stone, glass, metal, or other inorganic substance, provided it be equally rugged and irregular, and its edges equally sharp, will exhibit no more tendency to remain lodged in tissues of the human body with impunity than a fragment of wood or bone of similar outline and form.

It seems, therefore, that the circumstance of foreign bodies being capable of lodging in living tissues with comparative impunity, or otherwise, depends more upon conditions of substance, form, and surface, than upon their nature, as to whether they are organic or inorganic. The movements to which foreign bodies are subjected, either under the influence of the general changes in posture of the body, or of local muscular or other organic actions, and their effects upon the structures among which the substances happen to be lying, must also be taken into account in this view. It may easily be understood that a hard smooth material, like a leaden bullet when it retains its original form, if moved, will affect the structures amid which it is lodged very differently from a yielding foreign body with a rough surface like a piece of woollen cloth, or one with sharp edges and points like a splinter of wood or fragment of stone. It seems, indeed, not improbable that it is to these

causes in combination—to their qualities of surface and substance, and to the amount of movement of the parts in which they are placed—that the variable effects of lodged foreign bodies may principally be traced, so far as the lodged bodies themselves are concerned.

The effect of situation, and of the amount of movement of the parts, in which foreign bodies are lodged.—The part of the organism in which the foreign body is lodged has also a material influence on the effects of the lodgement. A different train of symptoms may be expected to ensue according as it lodges in the substance of a muscle, among the tissue connecting muscles, among tendons, in bone, within the capsule of an articulation, in a serous cavity, or in any of the viscera of the body. The special considerations to which these particular sites of lodgement give rise can only be properly estimated, however, when the wounds in the particular situations mentioned are separately studied.

The amount and kind of movement, which are natural to the structures implicated, will often have a material influence in determining whether irritation is set up in the neighbourhood of a lodged foreign body, even of irregular form, or whether it remains unnoticed, as it were, by the tissues adjoining it. If it be lodged in a part where very little movement occurs, it may rest quietly without creating any disturbance. I have before alluded to a case in which a small fragment of lead was torn away from a bullet during its passage through a part of the spinal column and was driven into the capsule of the spleen. According to the report written by Dr. Wilks at the time the post-mortem examination was made, no evidence was afforded of any mischief having resulted from its presence in the situation named. No after-effects of an inflammatory character were associated with the lodgement of the splinter. The adhesions that had been set up in consequence of the damage done to neighbouring parts by the main part of the bullet had, no doubt, kept the foreign body quiet in the bed which it formed for itself in the capsule of the spleen. The splinter of lead was not heavy enough to excite irritation by pressure.

When a bullet has lodged for a number of years in a lung without exciting irritation, it has generally been found to be encapsuled, and the peripheral part of the lung in its neighbourhood to be firmly adherent to the costal pleura. In this way the movement of the part of the lung in the immediate vicinity of the lodged projectile has been reduced to a minimum.

The irritating effects of movement of parts around a lodged projectile, or other foreign body, are frequently witnessed. In some instances no suspicion of the lodgement of a foreign body will be excited while the patient remains quiet in bed during the treatment of his wound. The wound may become closed toward the surface, but, when the patient begins to take exercise and the

movements of the parts concerned in the wound become more free and unimpeded, pain arises, pus collects, the wound reopens, and the presence of a foreign body becomes sufficiently evident. Or the same effect may result in cases where a bullet has been lying quiet for years, when prolonged or violent exertion is taken, and a great deal of movement is caused to occur among the parts around the projectile. An officer, residing near Netley, who was wounded in 1813 at the battle of Vittoria, had a bullet lodged deeply in the spinal muscles for 56 years. He suffered from abscess in the back twelve times during this period at various intervals. On each occasion the abscess occurred after unusual exertion, and generally healed under rest and ordinary treatment. The last occasion was in 1869, and happened after prolonged exercise on horseback. The bullet, this time, made its way to the surface and was removed.

Encystment and isolation of foreign bodies.—Whenever a foreign body remains lodged for a considerable time within some of the soft tissues of the body without exciting disturbance, it is always found to have become provided with a protecting envelope. Inflammatory lymph has been effused about its substance, and this becomes gradually converted into a dense, almost fibro-cartilaginous investment, shutting it off from direct contact with the organised structures around, and frequently, by its connections, restraining it from shifting its place of lodgement. The union between the capsule and the foreign body is sometimes exceedingly intimate, so much so that the separation of the one from the other in the operation of extracting a long-lodged foreign body is often a very difficult proceeding. Fibres of the capsule seem to enter minute openings of the surface, if the body be a spherical one; or are wound around projecting or twisted parts of it, if it should happen to have become deformed.

I can only explain the close union which thus occurs by supposing that some of the liquid plastic lymph, effused around the bullet as an early consequence of the inflammatory action excited by its presence, has then entered into the minute pore-like openings in the surface of the lead, or has surrounded irregularities in its outline, and that, after becoming solidified and condensed in common with the surrounding lymph, they act as prolongations of the substance of the investing capsule and so support the projectile within it. We may sometimes observe the tenacity with which a bullet is held by part of the inner wall of an old cyst, in preparations preserved in alcohol. Part of the cyst being removed to show the lodged bullet, the latter, notwithstanding its weight, is still retained within the open cyst, solely by the connections which exist between the leaden projectile and what remains of its capsule. Certain foreign bodies become more readily encysted than others. Dense metallic bodies with polished surfaces seem to

be particularly favourable for becoming enclosed in well-fitting capsules of dense fibro-cellular tissue: bodies with angular outlines and rough surfaces, on the contrary, very unfavourable to this process. Coarse woollen cloth and similar substances seem to exert some special counteracting influence that prevents them from being isolated by surrounding lymph deposits, and this perhaps mainly accounts for wounds in which such foreign bodies are lodged usually remaining unhealed. The same explanation which has already been given for foreign substances of the latter description having a more pernicious action when lodged in wounds than those with unyielding smooth surfaces, will probably explain their different tendencies as regards encapsulation.

Accidents to which encysted foreign bodies may give rise.—Although a bullet or other foreign body may remain for many years in a state of quietude by means of its encysted condition and other circumstances, a local injury, or even a deterioration in the state of general health of the person who is the subject of the lodgement, and, in consequence, a lessened power of resistance of the tissues among which the foreign body is lodged, may speedily convert this condition of inactivity into one of active mischief. Baron Larrey has recorded a case which well illustrates how a bullet, passively lodged, may be suddenly turned into an agent of serious mischief by local injury. A soldier was wounded by a musket bullet in the left shoulder. The ball penetrated deeply, and could not be found. The wound after a time became cicatrised, as if no lodgement had occurred; but, no doubt, with limitation to movement from anchylosis, though this is not stated. No further inconvenience was experienced until thirty-six years afterwards, when the man met with a fall in Paris. The shoulder which had been wounded came into collision with the pavement. The fall was at once followed by acute inflammation, and soon afterwards by the formation of pus within the articulation. Amputation was performed at the shoulder joint; and, on examination of the limb, the bullet was found enclosed in a cavity in the substance of the head of the humerus. No traces of lesion could be detected as a result from the long period of lodgement of the projectile in the bone; so that there was good reason for believing that it would have remained lying inertly in the bone as long as the patient lived, had it not been for the accident of his fall. Many examples of a corresponding nature might be quoted.

It is evident that the liability to such occurrences should weigh with surgeons when considering the subject of exploring for and extracting lodged foreign bodies.

Lodgement of gunpowder grains.—The fact that grains of unexploded gunpowder are propelled by the gases which result from the ignition of the grains that are exploded, and that the former are thus caused to act upon objects near at hand as pro-

jectiles, has been referred to in a previous chapter. When the grains of ordinary gunpowder used with portable fire-arms, or for bursting charges and other like purposes, are propelled in the manner described and strike an exposed surface of the body, a large proportion of them penetrate and remain lodged. They rarely lodge deeper, however, than in the substance of the true skin, or the areolar tissue immediately beneath it. When a quantity of gunpowder is exploded near to the face and neck of a person, so that these parts are struck by the gases, their surface is at first generally and deeply blackened. A small proportion of this blackness is caused by a superficial deposit of very fine particles in the form of smoke, and admits of removal by simple sponging. A certain quantity of the powder in the form of dust is driven into the substance of the epidermis. The complete grains are forced more deeply into the substance of the papillary layer, or probably for the most part into the areolar network of the corium beneath. If nothing be done to remove them earlier, in the course of three weeks or so, the time varying according to other circumstances accompanying the injury, the gunpowder dust, and such of the larger particles which have lodged in the superficial epidermal layers of the skin, will have come away, and with them the black colour will have disappeared also. The grains which have penetrated the derma, or still more deeply than the derma, remain lodged, and instead of a black colour, they present a more or less blue aspect. When once the epidermal layers are completely healed over them, the grains of powder do not cause any local irritation or inconvenience, though the nitre in the powder might *à priori* be expected to give rise to some smarting sensation. Although the face may be thickly studded with them, the patient is not aware of their presence so far as sensation is concerned. He cannot himself feel the grains of the powder by rubbing the surface, nor are they perceptible when the skin is touched by another person.

This was the case with a patient in whose face, perhaps, there were as many gunpowder grains lodged permanently as in any instance I ever met with. Sergeant A. Kiernan, of the Royal Artillery, was invalided from Mauritius for injuries resulting from a shell explosion. He was holding the shell, a 32-pounder, in his hands when it exploded, and was at the moment actually stooping over and examining it; yet he miraculously escaped with no other permanent injury than the loss of the forearm on one side, and of the thumb on the opposite side. His face was universally and densely studded with coarse-looking grains of gunpowder, but neither I nor the patient could feel any sensation of roughness or irregularity from them. If it had not been for the peculiar marking of the skin, no indication of the presence of the lodged particles would have been afforded.

I have not been able to satisfy myself as to the cause of the

blue colour of the lodged gunpowder grains. The blue colour is always more conspicuous in cold weather, probably only because the surrounding skin is paler. Nothing can well be blacker than gunpowder itself, especially when moistened.

CHAPTER II.

ULTERIOR CONSEQUENCES OF GUNSHOT WOUNDS IN PARTICULAR ANATOMICAL STRUCTURES OF THE BODY.

External cicatrices of gunshot wounds.—The cicatrix, which results from the passage of a projectile through the skin and soft subcutaneous tissues, presents very marked characters which remain conspicuous for the remainder of life. I have carefully observed a large number of such scars, and have come to the conclusion that, in almost all instances of entrance wounds in fleshy parts, the features presented are so characteristic as to cause them to be quite distinguishable from the scars of wounds originating in other sources of injury. When a bullet has lodged superficially in a bone which is covered by little more than skin and fascia, there is not the same facility of recognising the origin of the scar. The depressed and adherent cicatrix, which remains after the gunshot wound is healed, is not distinguishable from the cicatrix left by any other lesion in which partial loss of bone substance has occurred in the same situation.

When a spherical bullet has entered any of the soft parts of the body in a straight line, or with only a moderate degree of obliquity, the cicatrix presented is sometimes circular, sometimes oval, is depressed, with a white film on the surface and a central ridge, often of a pink colour, towards which white cicatricial lines radiate from the circumference. The cicatrix is more vascular, and therefore presents more of the pink colour at an early period after the wound is healed than it does later in life. If the bullet has entered with much obliquity, the depression of the cicatrix will be most marked at that part where the bullet has passed away into the deeper tissues. It will generally be pinker in colour at this situation, and the white cicatricial lines will converge towards it. Such a cicatrix will have a defined curvilinear margin bounding the part which is most depressed, while the surface of the cicatrix will gradually fade into the general level of the skin at the part opposite to it.

But the most characteristic sign of the cicatrix being one of a gunshot wound will be the disappearance of some of the support which normally should exist beneath the surface at the part where the wound has been inflicted. The end of the finger, on being

pressed against the cicatrix, sinks into a more or less marked cavity. This is especially due to loss of substance, or to a split-like opening, in the aponeurotic fascia, and to the skin at the edge of the cicatrix being adherent to the margin of the opening in that structure.

Some modifications will result from the form of the surface of the part at which the ball has entered, or the wound has been inflicted; the degree of firmness and thickness of the aponeurotic fascia beneath it, and the pliability of the skin; but the general features just described may be expected to be present. The action of muscles or other organs near the wound, and connections which the cicatrix may form with neighbouring parts, will also occasionally modify its appearance. A soldier of the 55th was wounded at the lower part of the neck in front by a bullet at the battle of Inkerman. When I examined this man in 1870, I found the cicatrix in the shape of a pouch, into which the finger could be inserted as into the finger of a glove. It was in front of the trachea, and went down to the depth of one inch and a half behind and below the upper edge of the sternum. Sometimes the cicatrix, in the act of healing, becomes intimately connected with the fibres of a subjacent muscle, and the cicatrix is puckered and drawn whenever the muscle is put into action. This gives rise to no particular inconvenience when the scar is a small one, but in extensive superficial wounds it is sometimes a source of much pain and trouble.

The cicatrix of the wound of exit is generally strongly marked, but rarely presents the same circumscribed outline, or cicatricial lines radiating from it with the same regularity, that characterise the wound of entrance. It is generally less depressed, sometimes not at all so, while the opening in the fascia can seldom be felt so plainly as it can be at the wound of entrance. The end of the finger cannot be pressed inwards at the cicatrix in the same way.

The irregularity in the general shape of the cicatrix of the wound of exit will be all the greater if bone has been fractured and the fragments driven by the projectile towards it. Such a cicatrix will usually be only partly adherent, and will be marked by central lines, somewhat raised, corresponding with the original lines of separation of the torn surface, and finer cicatricial lines from contraction, generally white in colour, radiating towards them.

The cicatrices resulting from wounds caused by fragments of shell vary in extent according to the size of the projectile by which each wound has been inflicted, the extent and depth to which sloughing has followed it, the situation of the wound, and other circumstances. The loss of substance with which such wounds are frequently accompanied, and the contractions which are formed in the process of healing, lead to much irregularity in the characters of the cicatrices, and the amount of deformity attending them. The contraction of such a cicatrix causes the tissues to be so drawn that there is always a tendency to ulceration in situations where

it is exposed to friction or contusion, especially when the cicatricial integument is non-vascular, thin, and is tightly bound down to the parts beneath, or is liable to be suddenly put on the stretch. Such cicatrices frequently become the sites of chronic ulcers which are very difficult to heal, and very liable to open again when they are closed.

The cicatrices of burns from explosions of gunpowder differ only from burns of the same depth from other causes by a certain amount of fine particles and grains of gunpowder being usually lodged in the skin and subcutaneous tissues. The persistence of the colour arising from the lodgement of these particles of gunpowder, and their general characters and effects, have already been noticed.

In many instances the superficial cicatrix of a rifleshot wound is quite free from all pain or uneasiness after the first tenderness has passed away. There may not be the same acuteness of sensation as exists in the adjoining skin, but the space is small, and the difference so little marked that it is not noticed. On the other hand, in some instances sensitiveness is increased, and remains so for many years, whenever the cicatrix happens to be touched. Sometimes, scars are affected by changes in the state of the atmosphere, especially when a cold and damp state follows the opposite conditions. I have known men who were compelled to protect the scars of gunshot wounds from pressure in order to prevent the production of pain—in whom a firm pressure of the cicatrix gave rise to a startling 'burning and shooting' sensation, while a brush or light pressure of the part excited uneasy sensations of another kind, which were sometimes referred to the cicatrix itself, sometimes to distant parts. Obviously in these instances some nerve fibres had become involved in the cicatricial tissue, or, if not actually held by it, had become so disposed in regard to it, as to be subjected to traction or pressure by its means under particular circumstances. Cicatricial connections with deeper organs may give rise to reflex irritation of remote parts. In one instance, a man came under my notice who had been shot through the chest. In this case slight pressure on the inverted and puckered cicatrix, which was in front of the chest, invariably produced cough.

Remote effects of gunshot wounds on fasciæ.—The openings made by gunshot projectiles in the fascial coverings rarely become closed: probably never when they have been made by projectiles the forms of which have not been changed, and which have effected their passage while preserving a high rate of speed. I have examined a very large number of healed bullet wounds, and in all without exception the opening in the fascia at the wound of entrance has been traceable by a little manipulation. The edges of the opening have become united with the margin of the opening in the skin, either wholly or in part, and with the cicatricial tissue

by which the deeper part of the track has become occluded; so that, on pressing the finger into the superficial cicatrix marking the entrance of the bullet through the skin, the margin of the fascial opening can be readily detected.

In some cases the persistence of the opening in the aponeurotic fascia after gunshot wounds has led to muscular herniæ. In two instances which came under my notice the muscular protrusions were readily reducible. They took place occasionally when the muscles were put into action, and then, after being protruded, on certain movements of the limbs, the protruding portions became nipped by the edges of the tendinous openings, and a sharp pain was the result. The protrusion in each case was easily returned when the muscle was relaxed, and its recurrence was prevented by the pressure of a pad applied on the same principle as a truss for ordinary hernial protrusions.

Remote effects of gunshot wounds on the connective tissue.—Not only are the mere appearances of the cicatrices of gunshot wounds modified by changes in the connective tissue beneath, but these changes often interfere with the free action of neighbouring parts, and impair their functional qualities. This is chiefly due to the fact of the pliable fibro-cellular connective tissue being replaced by the firm and compact fibrous tissue which constitutes the cicatrix, and which, deprived as it is of elasticity by reason of the absence of fat and from its closer texture, unites itself to the adjoining anatomical structures by a number of bands of a similar nature. These structures thus become more or less tied to the cicatrix of the wound, and more or less hampered in their movements. Such cicatrices never wholly disappear throughout life, but the restraint of movement becomes gradually lessened under the influence of use. The bands of adhesions become extended and lessened in size and firmness, and the parts thus acquire by degrees a more normal condition. In some instances there is a total disappearance of the true connective tissue. Thus, when the cicatrix in the skin becomes adherent to bone, or a puckered inverted cicatrix has become closely united to muscle, the connective tissue originally existing between their respective structures does not form afresh, but they remain coherent for the remainder of life. The loss of connective tissue is often very marked in wounds which have continued to suppurate for a long time, or in which sloughing of connective tissue occurred in the early period of the wound and extended to some distance beyond the direct track of the projectile. Under these circumstances the abnormal direct connections which are formed between adjoining structures, which were previously held together only by a yielding material admitting free exercise of their respective functions, unavoidably entail serious restrictions and diminution of power in the parts concerned.

The 'drag' of the parts held under restraint by these connect-

ing cicatricial bands becomes a frequent source of aching and pain when neighbouring muscles are put into action, or when certain positions of the limb or part of the body in which the wound is situated are assumed. When the projectile has also passed through the muscles which are put into action, it is difficult, or, rather, impossible, to determine how much the pain in movement is due to the alterations in the connective tissue and how much to those in the muscles themselves.

Remote effects of gunshot injuries on muscles.—Gunshot contusions of muscular tissues lead to impairment of muscular function in various ways. Sometimes gradual wasting, without any other marked symptom or evidence of lesion: sometimes paralysis, more or less complete; sometimes persistent pain, with wasting from disuse, is the consequence of contusions from gunshot. In other instances, the results of inflammatory action, such as contraction, or adhesions to neighbouring structures, may be the source of impaired function. When an atrophic condition of muscles occurs, the loss of power which results becomes a direct source of disability according to the situation and functions of the muscles concerned. Muscular atrophy may also indirectly entail other lesions of a disabling nature. Thus atrophy of a portion of the muscular walls of the abdomen from gunshot contusion occasionally gives rise to ventral hernia.

Wounds of muscles by gunshot vary in their effects according to the extent of the wound, the situation and particular functions of the muscles wounded, and other like circumstances. The track of a small projectile through a muscle, when the wound has healed favourably, becomes closed by ordinary fibro-cellular cicatricial tissue. This usually remains intimately connected with the cicatricial material by which the openings in the other structures have also become repaired. After a time, varying in duration according to circumstances, the cicatrix of the track becomes more and more contracted, while its connections with the cicatricial tissues at the opposite surfaces of the muscle become elongated, and the latter gradually regains greater freedom of action. So complete under favourable circumstances may this freedom become that no noticeable restraint may at last remain, but apparently complete power be regained.

Under other circumstances cicatrisation may so occur that this restoration of functional power may be wholly prevented. I have seen the triceps brachii so severed by a shot a few inches above its insertion into the olecranon, that each of the divided surfaces was widely separated, and in the process of cicatrisation became closely adherent to the humerus. The function of the muscle was thus wholly destroyed. Not only was all active power of extension of the forearm gone, but the power of flexion was prevented by the firm manner in which the ulna was fastened to the humerus, the

short closely adherent lower part of the triceps admitting of no muscular movement. Unfortunately, the arm had been allowed to get fixed during the healing process in a position of nearly full extension, and it became a question whether removal of the arm by amputation would not be a less evil than its retention in the stiff and extended position in which it was permanently fixed. In the instance of a relative of mine who was wounded at one of the assaults of Sebastopol, the shot made a deep gap across the muscles of the front of the arm, and this gap was extended by the subsequent action of gangrene. Here the power of flexing the forearm was lost, but fortunately full mobility of the elbow joint was retained, so that a slight artificial support of the forearm, such as its suspension by a ribbon carried round the neck, enables all the other movements of the arm, as well as those of the hand and fingers, to be serviceably performed. In many such cases not only is the function of the wounded muscles destroyed, but anchylosis, partial or complete, of neighbouring joints takes place during the prolonged period of treatment, or as a result of the cicatricial contractions consequent upon the wound. The use of the whole limb then becomes seriously impaired. It is evident that all gunshot wounds in which muscles are completely divided across must lead to impairment, if not to complete loss of their function, the effects of which will be more or less serious according to their situation. The cessation of muscular power will not only entail loss of action in those parts on which they had been used to exert their influence under normal circumstances, but will generally induce changes in the condition of their opponent muscles. They become affected by the loss of the antagonistic action which had been previously exerted by the injured muscles. In some instances they will be caused to act inordinately, leading to more or less alteration in form of the parts with which they are connected; in others they will undergo a process of wasting, and thus add to the weakness already due to the state of the wounded muscles; while in others again, they will become fixed, either in a state of flexion or extension, according to local circumstances, producing distortion and permanent loss of function.

Remote effects of gunshot injuries on tendons.—The division of tendons, whether partial or complete, by gunshot is usually followed by impaired or destroyed functional power of the muscles to which they belong. The union of the separated portions of the tendon itself is rarely if ever of such a nature as to allow the tendon to move freely again, while the healing process in the other wounded structures in the neighbourhood can hardly be accomplished without further impeding a restoration to normal action of the parts concerned in the injury.

If the tendon be not completely divided, but only partially so; or if it be severely bruised, and is not afterwards destroyed by

sloughing as a consequence of this contusion, the suppurative action which is set up generally ends in fixation of it in its sheath, and in adhesion of the sheath to the other structures in its neighbourhood. The free play of the tendon is prevented, and not only loss of function, but more or less deformity generally results. If a tendon be completely divided, the divided end, attached to the muscle to which it belongs, retracts to a considerable distance, and in the process of repair usually becomes united to a neighbouring bone, or to other adjoining structures, while the lower end becomes involved in the cicatricial tissue of the wound in the soft parts, or, if suitably situated, also becomes adherent to bone. In other instances both ends of the divided tendon become mixed up with the general cicatrix of the wound. The muscular function becomes very greatly impaired, or is entirely destroyed, and, of course, in the latter case the tendon ceases to exert any influence over the part into which it is inserted.

The function of a joint may be destroyed, as one consequence of the condition, just named, of neighbouring tendons. Thus, I have seen in various instances some of the extensor tendons of the fingers divided at the back of the hand, and from the manner in which the lower divided ends have become united to the metacarpal bones, owing to the hands having been kept in a straight position on splints during the healing process, the fingers have become rigidly extended. Flexion could not be produced owing to the fixed state of the lower ends of the extensor tendons. Had the hand not been maintained in an extended posture during the healing process, the function of the joints would have been equally lost, but permanent flexion would have been the condition presented.

Remote effects of gunshot injuries on bones.—The ulterior consequences of gunshot wounds of bones are oftentimes very troublesome and painful: even, in some instances, when the original injury has been in one of the limbs, to the extent of making patients regret that amputation had not been performed in the first instance.

Gunshot injuries of bones which have not been accompanied with fracture are followed, in many cases, by results which remain in a state of quietude for some years, and are then suddenly roused into action by accidental occurrences. Thus a certain amount of chronic thickening from periostitis or ostitis may last for years without pain or consciousness of impaired power; but under the effects of a lowered state of health, or under the influence of some fresh injury, inflammation may be excited. This, under proper care and treatment, may again subside into a state of quiet, but is very liable under other circumstances to pass on to some one of the morbid conditions to which inflammation of weakened bone structures is apt to give rise—either necrosis, caries, or osteomyelitis. When the injury has occurred to bones forming a joint, or to such

as are near to one, the original inflammation caused by it may have led to anchylosis, partial or complete. Not unfrequently the same result ensues from the effects of long-continued restraint of limbs in splints, during the treatment of gunshot fractures at remote distances from the articulations. Partial anchylosis often entails more trouble and suffering in its consequences than when it is complete, for fresh attacks of inflammation are easily excited by accidental falls, or by blows, on the impaired joints; and such patients have not the same facility of avoiding these injuries as persons in whom the corresponding members are in a healthy condition.

After a gunshot fracture has united, and muscular actions have been in a great measure restored, the bone remains more or less weakened for a considerable time. Although continuity is regained, consolidation remains imperfect. Refracture is likely to take place if the bone, under such circumstances, be subjected to strains which would produce hardly any injurious effect on the same bone in its normal state. An officer was wounded at Amoaful in the Ashanti War in January 1874. He sustained a severe fracture of the right humerus from a rifle shot. He rejoined the depôt of his regiment in September 1875, with the humerus apparently firmly united. One year afterwards, on the 15th of September 1876, while riding and holding the reins in the hand of the wounded side, a sudden jerk of the horse's head caused the humerus to snap across near the old site of injury. A private of the 42nd Regiment also had his humerus fractured by a shot in the same action. The missile in this case came from one of the old smooth-bore muskets used by the natives, and the fracture was of a trifling nature compared with that sustained by the officer previously mentioned. The broken bone was quickly united, and seemed to be quite strong when the man landed in England in April of the same year. On the 18th of June he had a struggle with a prisoner, when refracture of the bone occurred at the former place of injury. A private of the 10th Regiment was wounded in action at Perak in the Malay peninsula, on the 7th of November 1875. The right humerus was fractured. He returned to England in March 1876 with the bone apparently firmly united, but with the elbow, wrist, and finger joints almost completely anchylosed. In October 1876 an attempt was made to reduce the anchylosis of the elbow under chloroform, and while pressure was being made to bend the elbow, the humerus gave way and became broken again near the original wound. The refracture in these instances did not interfere in any way with a repetition of union.

Bones, which have become firmly consolidated after gunshot fracture, and in cases in which full power has seemed to have been restored and the wounds in the soft parts have remained sound for years, are still liable to elimination of sequestra when detached

splinters have been locked up in the new bone at the site of injury. I have elsewhere referred to the case of an officer who was under my care in the Crimea for a gunshot fracture of the thigh bone in the upper third of the femur, who, though he had been on active duty and quite well for a period of nearly eleven years, suddenly at the end of that time became the subject of tenderness, without any external exciting cause, near the scar at the spot where the bullet had entered. The soreness increased, was followed by a small abscess, and from this abscess, when opened, a small sequestrum, one inch in length, evidently one of the original splinters, was extracted.[1] The wound of escape healed as soon as the piece of bone was got rid of, and no further trouble has been since experienced. Many examples of splinters locked up in the copious irregularly shaped new bone, by which some of the specimens of gunshot fractures have been united, are to be seen in the museum at Netley. An examination of them will sufficiently show that such of them as by their form and situation were evidently completely detached at the time of the original injury are entirely necrosed; while others, which had probably retained some amount of periosteal connection, are also partially necrosed to a greater or less extent. As long as such fragments remain locked up in the new bony material, so long must the patient be liable to accidents connected with them. Of these the most favourable will be the occasional setting free of one or other of the fragments, its march to the surface, and final expulsion through the usual process of sequestral elimination. But under other circumstances the same series of unfavourable conditions may arise, which are apt to attend the presence of such foreign bodies as leaden or iron projectiles when they are lodged in bone. Many instances have been recorded in which these have remained dormant in bone for long periods of time, when an accidental violent injury has set up inflammatory action in their neighbourhood, followed by acute pain, abscess, constitutional irritation, and other ulterior results of the gravest description.

CHAPTER III.

ULTERIOR CONSEQUENCES OF GUNSHOT INJURIES IN PARTICULAR BODILY REGIONS.

The various *causes* which influence the remote consequences of gunshot wounds in particular regions or anatomical systems, can only be properly estimated when the primary effects of these injuries and their treatment are under consideration. But the general results which follow, and particularly those which lead to soldiers being disabled for further service, may be readily recapitulated.

For this purpose I will refer principally to the disabilities which have been noted among the men discharged from the service at the general invaliding hospitals at Chatham and Netley on account of the effects of gunshot injuries. A considerable proportion of these invalids have passed under my own notice.

Disabling consequences of gunshot injuries of the head.—There are few cases of gunshot injuries of the head, if superficial wounds of the scalp be excepted, which do not entail among their ultimate consequences some kind of cerebral disturbance. These consequences are usually rendered more apparent in hot than in temperate climates. Numerous instances have come under notice, at Fort Pitt and Netley, of men who were able to perform their duties in the ranks fairly well while in England, but who were found unable to continue at duty after they had moved with their regiments for service in India.

Wounds of the head leave behind them external marks which in many instances sufficiently indicate the nature of the injuries which have been inflicted. Not to mention slight scars limited to the scalp, others consist of cicatrices, often very irregular and extensive, adherent to bone beneath but without alteration of the cranial outline; of cicatrices accompanied with more or less depression from loss of substance, when portions of the outer table, or of both tables, of cranial bones have been removed by the shot or subsequently by necrosis; and, lastly, of cicatrices with depression from fragments of bone having been driven inwards. Wounds about the temporal region are occasionally attended by loss of a portion of the external ear, and the auditory canal is obliterated in the cicatrix. In some instances adherent cicatrices, when they are extensive, cause considerable interference with the natural movements of the head; a large cicatrix at the occiput preventing free movements of the head forward, another of the parietal region leading to retraction of the head downwards to the corresponding side. Not unfrequently in cases that have been of a severe character, there remains an expression of anxiety in the features of the face, or one of dulness and hebetude, which are very characteristic of cerebral disturbance.

When a portion of a cranial bone has been completely carried away, whether by the direct impact of the projectile or by the results of necrosis, the loss is not repaired by the formation of new bone. A tough cicatricial membranous tissue, varying in thickness in different cases, takes the place of the bone that has been lost. A depression remains in the place of the lost bone, and not unfrequently the membrane may be seen to move with the movements of the brain. These movements are more obvious when some fluid lies in the depressed cicatrix.

The manner in which the cerebral disturbance is manifested varies very greatly in different cases. Headache is one of the most

common symptoms, and this is sometimes intermittent, sometimes continuous. It varies in degree in different cases—from pains of the most intense character to merely slight uneasiness. The injury to the brain may also exhibit its effects in weakness, or loss of function, of one or more of the organs of hearing, sight, smell, and speech; or in simply diminished muscular power and sensory acuteness; or in more or less complete paralysis of the face, upper extremity, or of both upper and lower extremities, generally limited to one side. In other cases lessened mental power and intellectual activity are manifested: evidenced by dulness of apprehension, difficulty in forming and slowness in expressing ideas, and inability to fix or concentrate thought on subjects. The temperament of the individual is sometimes changed. The development of an excitable disposition is a common result. Slight causes produce irritation, and, not unfrequently, paroxysms of anger, in persons who were previously of a comparatively calm and easy temper. More or less loss of self-control is usually marked in such cases. In one case an officer who was previously of thoughtful and rather reticent habits, became conspicuous for his talkative disposition and tendency to risibility on occasions when there appeared to be little to excite laughter. In this case the injury was received on the vertex, but a fracture of the base of the skull was suspected.

The brain itself in almost every case seems to be physically weaker. Slight causes produce cerebral congestion and dizziness, especially exertion in a stooping condition. Over-stimulation of the organs of hearing by excessive noise, of the eyes by strong glare of light, or disturbance of sight by rapid cross movements of objects, cause cerebral uneasiness, and generally more or less mental bewilderment. Constipation, fatigue, anxiety, pressure of business, speedily give rise to confusion and headache. Solar heat cannot be so well tolerated as it could be before the injury. Anything that increases the impulse or hurries the circulation of blood within the head speedily produces exaggerated cerebral excitement. The use of stimulants in this way leads to very deleterious effects. The amount of alcoholic stimulant that could be taken before the wound with impunity, if now taken, speedily produces evidence of intoxication, such as loss of muscular control, and not unfrequently induces violent outbreaks of ill temper or delirium. Tight pressure about the head is ill borne, because it tends to impede the freedom of return of venous blood from the surface, and to produce more or less internal congestion.

Disabling results of gunshot injuries of the face.—Gunshot wounds of the face after cicatrisation leave behind them more or less deformity of the features. Such disfigurements are always sufficiently marked and distressing, when the wounds have been of a severe kind; occasionally they present a hideous and

truly repulsive aspect. As very extensive wounds of the face can be undergone without fatal results, these cases are by no means rare in the hospitals to which military invalids are sent. They are increased in number by the fact that the region of the face is that which most frequently suffers in cases of attempted, but unsuccessful, suicide by fire-arms among soldiers. In both polemical and suicidal wounds, important features of the face—the eye and eyelids, the nose, large portions of the cheeks, the lips, and considerable portions of the bones of the face, including the lower jaw—may be shot away, or removed by the after-effects of the injuries to which they have been subjected. The deformities produced by these ablations are in many instances aggravated by the changes and contractions which take place during the process of cicatrisation, and the bridling influence exerted by cicatricial bands on parts not directly concerned in the wound though adjoining it, especially on the upper part of the neck. The form and natural expressions of the face are quite destroyed in such cases, and a horribly mutilated spectacle is not unfrequently presented in its stead.

In some instances such deformities assume almost a grotesque character. In the case of one patient who had attempted suicide, the whole of one side of the face was mutilated, while the other was quite intact. On the mutilated side the globe of the eye, the lower part of the orbit, and a great part of the cheek were gone, an opening in the cicatricial tissue led into the mouth through a gap in the upper maxillary bone, and the soft coverings over the lower maxilla were extensively lacerated. The view of the man in profile on the one side being perfectly normal, a spectator was quite unprepared for the horrible deformity presented on the other side being turned toward him. In another case, also one of attempted suicide, half of the upper lip had been torn away from its connections, and had become united upwards towards the orbit in a line with the nose. The hair continued to grow as it had done when the lip was in its normal place. A huge gap, left by the loss of the eye, the lower part of the orbit, the malar bone, and a large portion of the upper maxilla, was covered over by a plastic operation; but the lip could not be wholly returned to its normal position, and the hair still grew in this situation.

Worse even than the pitiable condition to which such persons are reduced by the effects of their wounds in regard to appearance, is the loss of power of usefulness, enjoyment, and of general health, which they sometimes sustain from injury, or destruction of some of the important organs connected with the region of the face. Dimness of vision, or complete loss of sight in one or both eyes; obliteration of lacrymal ducts, ectropium, &c.; dulness of hearing or complete deafness, on one or both sides, from wounds involving the opening of the Eustachian tube, from wounds of the external ear and meatus and obliteration of the cavity by cica-

trices; loss of sense of smell; impairment, or loss, of power of speech, from wounds and cicatricial deviations of the tongue, destruction of the palate, &c.; defectiveness of articulation and pronunciation, from distortion or destruction of the upper dental arch, from loss of teeth, from loss or retraction of the upper lip; impairment of mastication, or total inability to masticate from loss of teeth; restraint of movement in the temporo-maxillary articulation, or its complete fixation, from anchylosis; limitation of movements of the lower jaw in consequence of cicatricial adhesions; loss of correlation between the upper and lower dental arches so that they cannot be brought opposite to each other, from ununited fractures of the lower jaw, &c.; interference with freedom of deglutition, from ablation of supporting structures and muscular deficiency, from cicatrices, openings of communication between the mouth and nasal fossæ, &c.; fistulous openings and loss of power of retaining the salivary secretions; loss of power of action in the facial muscles near the site of injury; facial neuralgia; all these serious disabilities result from gun-shot wounds in the face, and may exist, either separately or combined, to a greater or less extent according to the nature and amount of the structures which were involved in the original injury. With some of the consequences mentioned, impairment of the function of digestion is necessarily associated; so that when these exist, deterioration of general health must also be reckoned upon as one of the ultimate results of such wounds.

Wounds of the face, owing to the anatomical relations of this region, are sometimes associated with injuries to the base of the cranium, and thus some of the ultimate effects of injuries of the head are added to those peculiar to the region of the face itself. Even in cases where the facial lesion does not amount to a source of disability in itself, the effect of the cerebral concussion with which it was accompanied may be felt throughout life, and in the instances of soldiers may ultimately cause their discharge from the service. Private J. McC. suffered from a severe contusion of the right side of the face, and a small wound reaching to the lower part of the right ear. He was struck at the final assault of Sebastopol by a man's leg that had been carried off by a round shot. Insensibility, lasting for several days, and disturbance of mental faculties followed the injury. He recovered, so far as the injury to the face was concerned, with the exception of deafness in the right ear, owing to the external meatus becoming occluded by cicatricial tissue, and in February 1856 he joined his regimental depôt. He remained at regimental duty for eleven years, subject, however, to occasional attacks of giddiness, and always showing a certain amount of unsteadiness in the ranks. These symptoms increased to such an extent on the man being sent to India as to cause him to be discharged from further service.

The deformities from wounds of the face may sometimes be rectified by suitable plastic operations, and in some instances functional impairments lessened. In other cases artificial substitutes for parts which have been removed may be employed with advantage. Many ingenious contrivances were devised to replace deficiencies in parts of the upper maxilla and hard palate, and of portions of the lower jaw among invalids at Fort Pitt after the Crimean War. These substitutes for the lost natural parts did not merely improve the appearance of the men concerned, but they added to their power of mastication, deglutition, and articulation, thus increasing their means of preserving health and also promoting their comfort. M. Legouest has recorded the cases, and has given drawings, of some men at the Hôtel des Invalides at Paris, who survived many years after loss of the entire lower jaw and floor of the mouth, which had been carried away by grape or gunshot. Their condition was rendered less intolerable by the use of a metallic chin and plate to support the tongue and to conceal the deformity.

Disabling results of gunshot injuries of the neck.—Wounds of the neck, especially those which are caused by large projectiles, as fragments of shells, leave behind them not only contortions and restricted movements of the neck, but also forced inflexions of the head and lower jaws from the loss of substance and cicatricial contractions, to which they give rise. These effects vary according to the extent and situation of the adherent cicatrices. Such lacerated wounds being generally fatal when they are inflicted in the anterior part of the neck, it is chiefly after wounds of the posterior and lateral parts that these ultimate effects are met with. They are not unfrequently accompanied with cerebral symptoms similar to those which sometimes complicate the consequences of wounds of the face.

Both contusions and wounds of the lower and lateral parts of the neck are apt to be attended with injury to the cervical plexus of nerves; so that paralysis of motion and sensation, atrophy, contractions, and other results of nerve lesions, may be manifested in the arm on the side corresponding with that of the injury, and be some of the ultimate consequences which are met with after these wounds. Still more extensive paralysis, the effect of injury to some of the cerebral vertebræ, and of concussion of the cervical part of the spinal cord, is also one of the occasional consequences of wounds of this region.

Fistulous openings have sometimes remained when the larynx has been wounded, or a portion of the trachea has been carried away, without fatal results; and when the openings could not be closed by plastic operations, the permanent use of a canula has become necessary. The usual consequences of tracheotomy have been met with in other cases, where this operation has been performed in consequence of certain primary effects of wounds implicating the

larynx. Aphonia occasionally alone remains as the permanent result of wounds of the neck. A young lieutenant, who was under my care after having been shot from side to side through the œsophagus in the Crimea, recovered very favourably in all respects with the exception of impaired vocal power. It was hoped that this impairment might be lessened in time: but it was not, and he was eventually compelled, on rising to a higher rank, to quit the army solely in consequence of his inability to make himself heard at a sufficient distance. Irritable cough and difficulty of respiration are other consequences occasionally met with as permanent results of these injuries.

Disabling results of gunshot injuries of the chest.—Wounds of the chest, in which the pleural cavities have escaped from being opened, sometimes leave behind them much loss of substance and deep cicatricial contractions. These cicatrices more or less interfere with the free movements of the parietes, according to their situation and extent, and lead to dyspnœa and other ill consequences on exertion. Impaired use of one of the arms is not an unfrequent result when the cicatrix is situated at the upper part of the chest, whether in the pectoral or scapular region. Loss of substance of a portion of the ribs or sternum, with adherent cicatrices and tendency to ulceration, may also occur. Non-penetrating wounds, as well as penetrating wounds of the chest, are also occasionally followed by the disabling consequences of pleuritic inflammation, effusion of lymph, and adhesions, which had occurred as primary effects of the injuries. Impaired power of respiration, increased especially by exertion, pain, cough, flattening and other deformities of the chest, are permanent conditions originating in these causes. The number of invalids who are permanently disabled by the effects of gunshot wounds and contusions of the parietes and other non-penetrating injuries of the chest, appears to be disproportionably large by comparison with the small number disabled by penetrating wounds. The fatality of this latter class of wounds sufficiently explains the fact, as it also does the similar disproportion which exists in regard to the two corresponding classes of wounds in the region of the abdomen.

Disabling results of gunshot injuries of the abdomen.—Non-penetrating wounds and contusions of the abdomen are liable to be followed by muscular wasting and by protrusion of some of the viscera in unusual situations as well as in the ordinary positions of abdominal herniæ; by vesical paralysis, more or less complete; and visceral disturbances of various kinds according to the organs injured. In other cases where abscesses have formed between the abdominal muscular layers, even after they, or sinuses which may have followed them, have become healed, pain and restriction of certain movements of the body are occasional consequences. When peritoneal inflammation has been excited, adhesions are apt to

result; and these lead to local symptoms of uneasiness and pain, to obstinate constipation, and more or less interference with digestion, according to the situation and extent of the adhesions in question. The symptoms, perhaps, will only occasionally assume an urgent character, but the patient will probably remain subject to them throughout life.

Penetrating wounds of the abdomen, in which parts of the walls have been carried away by shot, and perforating wounds, when recovery takes place, are liable to be followed by artificial anus which, though closing for a time, is likely under various circumstances, to re-open. Or they leave behind them deep adherent cicatrices, which give rise to inconvenience more or less considerable according to their position and extent, sometimes leading to a bent position forward, an erect position being impossible, or possible only for a short time, and then with much pain. If the cicatrix be at the lower part of the abdomen and is extensive, it will occasionally entail permanent flexion of the thigh and abdomen towards each other, with, of course, impediment to marching. Deeper visceral adhesions may cause pain in certain movements of the body, inability to bear tight pressure as from a waistbelt, irregular action of the bowels, constriction of intestine, obstipation, occasional attacks of colicky pain, and other symptoms. Hernial tumours are also one of the results of these open wounds, as well as of the contusions before mentioned; and when the cicatrix is large and thin and soft, as sometimes happens in this region after shelving penetrating wounds, much difficulty is experienced in preventing the escape of viscera from the abdominal cavity by any artificial appliance. Tenderness of the cicatrix, and tendency to ulceration, act as impediments to the use of trusses, however well fitted, when they make sufficient pressure to prevent protrusion.

In the very few cases in which small projectiles have lodged in the cavity of the abdomen and the patients have survived, there do not seem to have been presented any permanent symptoms beyond those which are apt to accompany peritoneal adhesions consequent upon penetrating gunshot wounds without lodgement of foreign bodies. In the case of an officer who was wounded in India in 1858 during the mutiny, and who died suddenly in 1865 at Portsmouth from strangulation and obstruction of the bowels, there had been no indication of the lodgement of the projectile which was found after death in the right hypogastric region.[5] He had been treated every now and then for attacks of obstinate constipation, but had not complained of any other symptoms. In several cases of men discharged from the service at Fort Pitt and Netley, the circumstances of the wounds have given grounds for suspecting lodgement in the cavity of the abdomen of the projectiles by which they had been caused, but no symptoms were presented that would enable the suspicions to be verified.

Disabling results of gunshot injuries of the back and spine.—Flesh wounds of the back entail the usual effects arising from loss of substance, cicatricial contractions, and adhesions according to their extent, in limiting the natural movements of the parts concerned. Contusions of the spine, if severe, as well as wounds in which the shot has penetrated and led to fracture of portions of some of the vertebræ, when life has not been sacrificed by some of the primary consequences of the injury, cause spinal weakness, deformity, and almost invariably induce a certain amount of paralysis, wasting, and proportionate debility in the lower extremities. These symptoms are rarely recovered from wholly, however long the life of the invalid may be prolonged.

Disabling results of gunshot injuries of the genito-urinary organs. The ulterior consequences of wounds which cause ablation of the principal parts of the external genito-urinary organs, occurring as they usually do in young men or men in the prime of life, are of a very sad and depressing character. They generally cause persistent melancholy, and in various instances have led to suicidal attempts. Simple contusions of the organs in some cases lead to wasting of one or both testes; in others to neuralgia, or varicocele, of the spermatic chord; to incontinence of urine; stricture of the urethra; contractions of the penis consequent on abscess; and other lesions. Complete loss of the whole external organs, or of the penis, or of one or both testicles, occasionally results from projectiles of the larger kinds. Removal of one testicle by a shot is very frequently followed by atrophy of the remaining testicle. Other permanent effects of shot wounds in this region are urinary fistulæ; cicatricial contractions and deviations of the penis from wounds of one of the corpora cavernosa; urethral stricture; and partial occlusion of the urethra by cicatricial bands.

Wounds of the external generative organs are very constantly complicated with lacerations of the perineum or of the soft structures on the inner aspect of one or other thigh, or of both thighs. Muscular retraction and impediments to movement of the limbs concerned, with lameness in walking, are the usual results in the latter cases.

Disabling results of gunshot injuries of the extremities.—Wounds of the extremities, unaccompanied by fracture of bone, entail consequences which interfere with the proper performance of their functions in very variable degrees. The permanent effects, which have been already noticed, of wounds and injuries affecting the cutaneous, muscular, and tendinous structures in all parts of the body, in the regions of the extremities, affect, more or less materially, the use of neighbouring joints, and the free exercise of the limbs in which they are situated. These results sometimes disable soldiers for the due discharge of their special military occupations, such as marching, riding, handling of fire-arms or

other weapons; and not only so, but in many instances impair, and sometimes altogether destroy, their power of earning a livelihood by practising the trades, or doing the work, to which they had been habituated before enlistment.

Still more is this the case when the wounds have been accompanied with fracture of bones which, either from the nature of the fracture, from occurrences during the course of treatment, or from the manner in which union has taken place, have led, as so often happens after gunshot fractures, to shortening and distortion, or to loss of power of sustaining weight, or loss of movement in the limb to which the bones belong, owing to atrophic changes, stiffness of neighbouring joints, or adhesion of tegumentary cicatrices at the seat of fracture; or in which the injuries have been of such a nature as to have caused amputation to be necessary. In some of the instances above mentioned, in addition to the permanent results of the fracture itself, the invalids are liable to many accidental complications, such as ulceration of the cicatricial tissues adherent to the bone at the site of fracture; pain in the injured limb, sometimes persistent, sometimes variable, sometimes induced by certain states of weather or of health; wasting of muscular tissues; affections of the opposite limb from inordinate or ill-balanced exertion; and other untoward circumstances. The lameness due to shortening after gunshot fractures, especially after those of the femur, is often very considerable, and materially affects the after-usefulness of the injured limbs.

Anchylosis, partial or complete, may result from contusions and wounds of any of the joints of either the upper or lower extremities: partial anchylosis entailing impairment of function of the joint according to the amount of abnormal fixation of the joint surfaces, as well as liability to accessions of inflammation and pain from slight injuries; complete anchylosis, causing complete loss of function of the joint (though in some instances this function is partially replaced by substituted or increased action of the neighbouring parts), and wasting of the structures previously concerned in its movements. The amount of infirmity depending on these results varies according to the size and situation of the joint injured.

When resection of an injured joint has been performed, the nature of the ultimate results of the operation, and so the amount of disability, will be influenced by the mischief done by the projectile to adjoining anatomical structures, especially to neighbouring nerves, the skill with which the operation has been performed, the kind of after-treatment adopted, and circumstances affecting the constitutional state of health of the patient while the treatment has been in progress. In successful cases of resection there is not unfrequently a continued gain in strength, mobility, and usefulness in the mutilated member for many years after the healing process has been complete. In other instances, on the contrary, either

from atrophic changes, from neglect, or disuse, or from repeated accessions of local inflammatory action induced by injuries rendered almost unavoidable by the diminished power and activity of the member itself, the amount of usefulness, which was obtained at an early period after the operation wounds had healed, becomes lessened, or even entirely lost.

After exarticulation of a limb, or amputation of part of a limb, it is almost needless to observe that a soldier is rendered useless for all active professional duties. Exarticulation and amputation also impair his future usefulness in civil life according to the member removed, and the nature of the trade or occupation to which the man had been brought up, and by means of which, if he were in a sound state, he could still obtain a living. Stumps left by amputation are often subject to tenderness on pressure, pain, ulceration of cicatrices, abscess, exfoliation of bone from moderate injury, and other accidents throughout life.

Extremely pitiable is the condition to which patients are permanently reduced after double amputations, which, as heretofore mentioned, are by no means very unfrequent results of war injuries. Life has been preserved after treble amputations, and even after the extreme mutilation of both upper and of both lower extremities, the patient, in the latter case, being reduced to so hopeless a state of infirmity and helplessness as to make it questionable whether the preservation of life itself is indeed desirable under such circumstances.

Disabling effects of gunshot injuries to blood-vessels.—Wounds of arteries, when the treatment of them has been attended with successful results, do not as a rule lead to ulterior consequences of a disabling nature. The circulation, which has been arrested in the direction of the wounded artery, is re-established through collateral branches, and no trouble is experienced. Contusions and wounds of the larger veins are occasionally followed by permanent distension of the vessels at the seat of injury, sometimes by a tortuous and varicose condition of the venous system below it, together with the tendency to œdema which is a usual consequence of such an interruption to the normal return of blood. In the majority of cases, however, when a vein is wounded, it becomes completely obliterated, and the return of blood takes place through other veins, either superficial or deep, with little or no permanent ill effects in consequence.

Disabling effects of gunshot injuries to nerves.—The ultimate consequences of contusions and wounds of nerves present many varied forms, and are often of a very distressing character. Among them are neuralgia, sometimes extremely acute, more or less persistent, sometimes disappearing with the lapse of time, sometimes lasting throughout life; severe cramps and shooting pains; impairment or total loss of power of motion, or of

sensation, or of both, in the parts supplied by the wounded nerves, sometimes involving a whole extremity; diminished temperature, alterations in colour, texture and secretions, hyperæsthesia, liability to eruptions and ulcerations, and other nutritive changes in the surfaces of the parts supplied by the injured nerves, with shrinking of the deeper tissues; permanent flexion, or extension, of portions of the extremities, and stiffness of joints; paralysis agitans, increased under states of excitement; ganglion-like and painful enlargements at the site of injury, and other affections.

The power of sensation and motion is slowly recovered in some instances, perhaps with severe pain in the course of the injured nerve; but, in other cases, in which the nature of the wound does not admit of the continuity of the nerve being restored, the paralysis remains unchanged throughout life.

SECTION VIII.

GENERAL TREATMENT OF GUNSHOT INJURIES IN FIELD PRACTICE.

CHAPTER I.

FIRST HELP TO WOUNDED.

Nature of help required.—The circumstances of battles vary so greatly in the nature, physical features, and extent of the ground over which they are fought; in the number, tactical disposal, and movements of the troops engaged; in the duration of the fighting, especially as regards the time when it ceases, whether leaving some hours of daylight or only stopping when darkness has set in; in the opportunities for making previous hospital preparations; and many other such matters, that no set rules can be laid down as to the time when the first professional assistance can be given to the wounded, nor even, in many respects, as to the manner in which this aid shall be afforded. But it is an established principle in all regular armies, that, whenever circumstances admit of it, the wounded, as they fall back from the ground where the action is being fought, are to have their wounds professionally examined, and to receive, if necessary, a certain amount of professional surgical treatment preliminary to their being transported to the field hospitals: which, in European warfare at least, will almost invariably be established at a considerable distance in rear of the field of battle itself, owing to the great range of modern projectiles. The moral effect of this arrangement among troops is probably no less important than the beneficial effect from a surgical point of view. In many instances, in which the injuries presented are found to be simple flesh wounds, without bleeding or any important complication, no application to the wounded parts will be necessary, nor any other treatment be required; the patients can proceed unassisted, without delay, or after a very short rest, to the place where the nearest field-hospital is established. Even in these

cases a word of assurance from the surgeon will often be a source of much comfort to the wounded men. In other cases of more gravity, some surgical operations may be urgently necessary; parts extensively lacerated may require to be replaced and secured; a portion of a limb left hanging by a few tissues, to be completely detached; hæmorrhage from important vessels to be stopped; and fractured bones may require support. In others, again, some provisional dressings will require to be applied; and, not unfrequently, some special directions to the bearers of the wounded will be necessary, some instructions serving to prevent risk of further hæmorrhage, or perhaps to avert aggravation of the original injury from malposition, or from avoidable movement in the course of the conveyance from the vicinity of the battle-field to a field-hospital.

While a battle is in progress, these precautionary measures are put into execution by surgeons placed in the most convenient positions available for that purpose, but generally selected on certain definite principles which will be explained hereafter in the chapters on organisation and administration of medical service in the field. Some primary help may be given immediately in rear of the place of fighting, but the principal provisional assistance will be afforded at the 'dressing-stations,'—stations sufficiently near to admit of early and speedy help to the wounded as fast as they are brought to the surgeons, and, at the same time, sufficiently far from the field of action and screened from exposure as to protect both surgeons and patients from undue risk of injury from shot.

Preliminary examination of wounds.—Whatever the arrangements for attending to the first necessities of wounded men may be, the preliminary examination of their wounds at the advanced dressing stations should be only cursory and general; the special diagnosis must be established further in rear, where there will be more appliances and more time at disposal for the work. But though the examination is to be one only for general observation, it must be conducted on fixed principles, and with a definite object in each instance. It should not be made roughly, though, in consideration for other patients, it must be made quickly. If the direction of a bullet wound is not obviously apparent, its situation must be sought for without loss of time, but yet with due care. More clothing should never be removed in any case than is absolutely necessary to expose the wound, either on the field itself, or, under ordinary circumstances, after arrival at a field-hospital. In campaigning it will not often happen that a wounded soldier is able to replace articles that are cast away or are much torn; and, if the season be cold, some time may elapse before the patient can obtain blankets or other articles necessary for preserving a proper amount of warmth. At the advanced lines of help, no clothes at all should be removed; they should only be opened, whether

for the purpose of exposing the wound to view or removing constriction. If a bone be fractured, the temporary supports should be placed outside the uniform: unless some special cause, as hæmorrhage, enforces the need for uncovering the seat of injury. The removal of the uniform should be deferred until after the wounded man has reached the field-hospital, whenever practicable. The removal of clothes on or near to the field of action itself can only be done with difficulty; it delays the removal of the patient to the place where his wants can be best attended to; and it takes up the time of surgeons and attendants, and proportionably prevents attention to some others of the numerous calls which will be certainly made upon them at such a time. Whenever there are imperative reasons for immediate exposure of a wound, instead of removing the uniform covering the wounded part, if the wound be in one of the extremities, the stitching of the seams of the sleeve or trouser, and of any undergarment, should be speedily divided by the knife or scissors of a hospital bearer or attendant to an extent sufficient for the exposure required. If the wound be in the foot, the backs of the boot and the sock should be divided: on no account should attempts be made to remove the boots by pulling them forcibly off. The general principle in the field should be so to open all coverings, when circumstances require it to be done, as fully to expose the injury or wound, but, at the same time, to leave the coverings in such a state that they may still be made use of until fresh clothing can be obtained. In field surgical practice such matters are by no means trifling, for they often have an important influence on the patient's subsequent welfare.

Objects of the preliminary examination of wounds.—One of the principal objects of the preliminary examination is to determine whether hæmorrhage is going on, or is likely to occur during the further removal of the patient, so that it may be at once stopped in the former case, and steps be taken to prevent its occurrence in the latter. The next object, should the complication of hæmorrhage not be noticeable, is to ascertain whether any, and what, provisional treatment will improve the general state of the patient, diminish the dangers and discomforts of his wound, according to its local peculiarities, and more especially to determine what local dressings or supports are needed to obviate the risk of additional injury during his transport further to the rear, or during the interval which may elapse before he will again come under surgical observation and care.

The provisional treatment of wounded men.—All provisional treatment, when there is no active bleeding to demand the surgeon's interference, should be of the simplest kind and such as can be carried out with great celerity. Elaborate appliances, dressings that require a considerable time for arranging them, are quite out of place. As a general rule, there are too many wounded, and too

few surgeons, and the means are altogether insufficient for such attention to be given to individual cases. The principle must always be kept in mind that it is the duty of the surgeon at the first and second lines of surgical aid to pass on, as quickly as possible, every wounded man that can be sent to the field-hospitals in the rear with safety. Cases in which there is imminent risk to life, unless some professional operation be immediately resorted to, are the only exceptions to this rule; these latter cases of urgent need cannot be sent away so speedily, but to such, even at the first line of assistance, the surgeon must devote all available time and attention. But even this precept must be followed with a certain reserve, for no surgical operation that will require much time in its performance should be undertaken; the movements of troops engaged in action are so uncertain, that the surgeon may not be able to complete it, and the patient may be left in a worse state than if the operation had not been begun. With the exception then of the most indispensable surgical operations, and such as can be speedily accomplished, whatever the surgeons at the most advanced lines of help may do in the way of surgical assistance should be done 'off-hand,' and should be directed principally to the prevention of additional injury during the passage to the field hospitals, where complete and accurate examination of the nature of the wound can alone be made, and where the patients can remain at rest, for some time at least, after having been subjected to the required treatment. Clearing away by the hand any clot that may interfere with a general view of the wound; the removal of any missiles or foreign bodies, which may be plainly obvious to sight or touch, especially such as are in situations involving hazard to the patient,—a jagged and sharp-edged fragment of shell lying near an artery, or other important structures, for example; the application of a piece of lint, or pad of carbolised tow, to the wound, secured for the moment in whatever may be the most ready way, by a short strip of linen and pins, by the triangular bandage, the use of an ordinary handkerchief, by anything, in short, that will keep the pad in its place and prevent undue movement of the parts concerned in the injury; temporary arrangement of any available support, whatever may be at hand, for a broken limb: protection of the wound against dust, cold, or other objectionable circumstances likely to present themselves in the transit, if these matters have not been already attended to, or only imperfectly carried into execution by the bearers; if shock exist, and it be not a case where its prolongation may be of service, as in likelihood of bleeding, the administration of a little alcoholic stimulant, wine, rum, brandy, in water, or, in their absence, some aromatic ammonia, or some similar restorative, for its relief; if there be debility and exhaustion from loss of blood, fasting, cold, or other causes, and circumstances have allowed it to be got ready (a rare contingency, however,

while an action is in progress), the supply of a little nutriment in the shape of meat essence; these acts of primary attention require little time for their execution, and will prove sources of comfort, perhaps of great service, to the patient.

If the piece of lint applied to a wound is moistened with water, and can be maintained so, until the patient reaches a field-hospital, it will be less irritating to the part, and less troublesome and painful to remove than lint applied dry. Several hours may elapse before the wounded man can reach the field hospital, and the dry lint by that time will probably have become firmly fastened by hardened clot to the edges of the wound and surrounding skin. When clean water cannot be obtained, as sometimes happens in the field, or if lint be scarce, a small fold of a cotton or linen bandage steeped in oil and covered with oiled silk, forms a convenient substitute. The piece of lint contained in the 'first field-dressing' supplied to each soldier on taking the field in the Ashanti expedition under Sir Garnet Wolseley, was spread with simple ointment and was wrapped in waxed paper. This answered the same purpose, when applied, as the oiled linen and oiled silk above mentioned. Surgeon-Major Wyatt has mentioned that a combination of glycerine and water on charpie was found to be the best application for immediate use to wounds in the battle-fields round Paris in 1870-71, when the subsequent transport to the ambulances was long and tedious. The purpose served was obviously the same: the glycerine prevented the dressing from becoming stiff and harsh and adherent to the wound and its neighbourhood. Surgeon-Major R. Wolseley has suggested that the Rangoon oil, a bottle of which forms part of each soldier's kit for firelock purposes, should be carbolised, and that soldiers should be instructed to wet the bandage in the 'first field-dressing' with the oil, and then to apply it to any wound that may happen to them.[1]

Voluminous bandaging of wounds should especially be avoided in the field. The covering will have to be removed when the patient arrives at hospital; so that, not only will the application of it be a waste of time which might be far more profitably spent, but the removal of it afterwards will be a source of needless additional trouble to attendants, and pain to the patient. The able and experienced Mr. Guthrie published some 'Directions to Army Surgeons on the Field of Battle' at the time of the outbreak of the Crimean War, and one of them was the following:—'Bandages or rollers applied on the field of battle are, in general, so many things wasted, as they become dirty and stiff, and are usually cut away and destroyed without having been really useful.' Nothing can be more true than this assertion, when roller bandages are hastily and voluminously rolled around freshly wounded limbs.

The simple provisional dressings already mentioned will answer all the purposes of roller bandages, and, with them, all that

need be thrown away is the pad of lint directly applied to the orifice or surface of the wound. This cannot be made use of a second time under any circumstances, nor would it be a saving worth mentioning if it could be.

The means of applying a temporary protection to every wound will not be wanting if the 'first field-dressing' has been issued to the troops on taking the field, according to the established regulations. But should this precautionary measure have been accidentally omitted, and the wounded be numerous, occasions may occur when the surgical materials, and the medicines, and medical comforts, at the disposal of the surgeons at the first line of assistance will be expended, while many patients still remain unattended to. It is satisfactory to reflect that even under these circumstances (circumstances which have so often happened in war that they may well happen again), the most necessary help can still be given to those to whom surgical aid is really of essential importance. A ligature, or a compress of any material at hand secured by a handkerchief, can be applied to a bleeding vessel; supports can still be improvised from a variety of articles for a broken limb, and these will form the majority of the cases in which primary attention in the field is a matter of urgent necessity. The soldier with a simple wound will not suffer much even though no dressing or covering be applied to it. The patient who has fallen from shock, or from faintness, will recover from gradual restoration of circulatory action where he lies, or may be carried away on a stretcher without material harm resulting from his condition; in some particular instances even with more advantage than if he had been roused from it by the administration of some of the usual remedies. If the transport arrangements have been well organised, no interval of time worth serious consideration as regards its influence on wounds of comparatively minor degrees of gravity will elapse, before the necessary care and attention can be afforded to them at the field-hospitals. In the meantime the surgeons in the immediate vicinity of the fighting and at the most advanced dressing stations, will be devoting their energies in favour of the badly wounded who most require their aid.

Removal of wounded after an action is concluded.—It is desirable that a preliminary examination, such as has just been described, should be made of each wound, and similar precautionary treatment adopted, when circumstances have prevented wounded men from being attended to while an action has been in progress, and when they remain to be cleared away from the ground after the conclusion of the battle. Under such circumstances wheeled ambulance conveyances will frequently be able to be brought up near to the ground over which the wounded are scattered, or may even be brought upon the ground itself close to the wounded men. The serious duty of collecting and removing

wounded men from fields of action should not, however, be solely entrusted to the attendants who accompany these conveyances, as is sometimes done; it ought, whenever possible, to be performed under the supervision of a medical officer. Many questions arise on such occasions which demand settlement without any delay, and which can only be settled, with due regard to the interests of the wounded, by professional decision. If any of the men who are picked up are to be moved to the hospitals on mule seats or litters, the medical officer should make such arrangements as will enable him to see that the most suitable cases are selected for such comparatively trying modes of conveyance, and that all essentials as regards their protection are attended to before they quit the ground. If the removal is to be by wheeled vehicles, the wounded, as they are brought on the stretchers to the wagons, should receive similar observation and attention before they are lifted into their places in them. It is not to be forgotten that many of the wounded will have been lying long unattended to, and that they will be suffering proportionately from prostration, probably mental as well as physical.

The charge which devolves personally upon the medical officer as regards this preliminary attention will vary greatly according to the amount of training, experience, and conduct of the bearers, or hospital attendants, acting under his directions. Well-trained and efficient bearers will leave little to be done by the medical officer in all but exceptional cases; inefficient bearers will leave everything to be done by the medical officer—often, in the interest of the sufferers, causing him to have to undo what they from their incompetency have done wrongly. The aptness of manner with which this preliminary duty is accomplished, notwithstanding the pressure for time which almost always exists on occasions of sending wounded men away from fields of action, not only forms a test of the expertness of the field surgeon concerned, but is often a matter of vital importance to the patients. There is not the delay that is caused when wounded men have to be carried long distances by hand before a regular transport vehicle can be reached, but there is frequently much delay nevertheless from other causes. It is a duty which often takes a long time to perform, owing to the extent of ground over which the wounded are scattered, and frequently also on account of their numbers; it is one, too, which has usually to be performed when the day is considerably advanced and darkness is approaching, if it has not already occurred. The hospitals to which the wounded are to be transported will not unfrequently be in villages, towns, or camps, three or four miles, if not further, to the rear; and from their distance, and also owing to the blocking up of the usual routes of communication by military vehicles of all kinds, not to mention other impediments to free locomotion at such a time,

especially at night, many hours must in all probability elapse before the opportunity will again occur of affording to the wounded men professional care and assistance. If the surgeon should know that the wounded can be rapidly conveyed to hospitals where surgical care and attendance, and all things proper for their injuries, will be certainly forthcoming, where too they will probably be free, for several days at least, from subsequent disturbance, he may send them away without any hesitation or delay; but if he is uncertain on these points, he should manifestly take special care to provide against all possible contingencies, and do all that he consistently can for their wounds and injuries before he allows the patients to leave him.

There is another reason why the presence of surgeons is needed when the duty of clearing fields of action is being performed. In occasional instances, in which the wounds are not of such a nature as to be manifestly destructive to life, doubts will arise whether men have really succumbed to the effects of their injuries and are dead, or whether they are only in a state of unconsciousness or powerlessness, from syncope, extreme shock, coma, or some other cause. Numerous instances have been recorded of men being left for dead on fields of battle, but who, from an accidental observation by a surgeon, or from a casual movement, or from some particular occurrence at the time of collection for burial, have been discovered to be still alive. This has especially happened in cases of injuries to the head which have deprived soldiers both of power of motion and of consciousness, and in cases of prolonged syncope from loss of blood. The questions which arise on these matters can only be settled by professional examination, and the bearers or other persons around will naturally look for a surgeon to decide them.[2]

Assuaging thirst of wounded men.—I have elsewhere referred to the urgent thirst from which most men wounded in warfare suffer. Care is usually taken that soldiers, when preparing to go into action, have their water-bottles filled, but this supply is often exhausted before the action begins. The orderlies who carry the 'medical field companions,' are also provided with a supply of drinking water, but the quantity that can be carried is unavoidably so limited compared with the demand, that its economical distribution, when there are not easy means at hand for replenishing the water-bottles, requires attention. Water is the natural beverage for relieving thirst, and under ordinary circumstances is the only one that should be used among wounded in the field. Spirituous stimulants do not quench thirst, and, as a general rule, when given merely for drinking purposes, are hurtful. In assuaging the thirst of wounded men, regard should be had to the circumstances of the time. In warm weather the coldest water from a spring will be the most grateful and the most appropriate; in winter, cold

drinks are in a great degree hurtful. Experience proved this latter fact, during the winter months of 1854–55, among the men wounded in the trenches before Sebastopol, and the truth of it was again noticed in the winter portion of the Franco-German War of 1870–71. The depression of nervous energy, and of the temperature of the surface of the body, by exposure to cold; the aggravation of these depressed conditions when there has been loss of blood; naturally indicate that whatever beverages are given should be in a state to add warmth to the frame, and, within due bounds, vigour to the circulation. Warm weak tea or coffee, warm broth, are really the only suitable beverages under such circumstances, but the means of supplying them can scarcely ever exist while fighting is in progress, and but rarely so in the places from which the wounded are removed after the fighting is over; still, if circumstances ever admit of their being given, the opportunity should not be neglected. They are restoratives of vital importance. They become all the more essential when a wounded soldier has remained long without any attention, when he has been lying on wet ground, or exposed to rain or snow. Spirituous stimulants may often be given with benefit under these special circumstances, when other liquid restoratives are not at hand; but they should be administered cautiously, only in small quantity, and then diluted with water. If it be possible to combine them with heated water, their effect will be all the more advantageous.

Attention required in cases of hæmorrhage.—Under any circumstances, whenever a wound with active bleeding is brought to the notice of a surgeon in the field, whether at the first or second line of assistance, the case should always receive his most careful attention. If the bleeding is proceeding from only small arterial branches, some pads of lint or tow and moderate pressure by a bandage will in most cases arrest it; if it be venous, it will be probably found that there is an impediment to the return of the blood through some of the adjoining veins, owing to the pressure of tightly fitting parts of the man's uniform, when the release of these obstructions, with the application of an ordinary pad and support, will be sufficient to arrest it. If, however, the hæmorrhage is occurring from injury to a large vessel, it must receive more deliberate treatment. The surgeon should not trust in such a case to styptics and plugging, which will probably only irritate the wound, cause diffused infiltration, and conceal what is going on in it; nor even, whenever it can be avoided, to the pressure of a tourniquet; but he should invariably, if possible, secure the wounded vessel at once by ligature. To send a patient away, who is known to have had one of the larger sized arteries opened, without this safeguard and depending on a tourniquet, even in broad daylight, but especially at night, would expose him, during his transport and while in the hands of, at the best, imperfectly informed

attendants, to the risk of the instrument becoming disarranged or loosened. The patient's life might consequently be endangered, either by gradual loss of blood or by sudden hæmorrhage. And, again, if the tourniquet retain its position, the circumstances of warfare are so changeable and uncertain, that many hours, if not a day or two, may elapse before the patient is seen by another surgeon. In the meantime some of the ill results of strangulation of the limb may have begun to be developed. So many accidents have occurred from the causes just referred to, that every field surgeon should hold it to be a sacred duty to secure by ligature, whenever practicable, all wounded vessels of importance that can be got at, before the patients are sent away from his own direct observation. In these cases, too, especial care should be taken to ascertain that the ligatures are firmly and properly applied. A ligature that may remain on an artery, although indifferently secured, when a patient is placed quietly in a hospital bed and is free from all sources of disturbance, may easily become detached through the shaking of transport vehicles over bad roads, or some of the numerous other jarring conditions to which patients are subjected under the rough circumstances inseparable from military operations in time of war, and thus give rise to recurrence of hæmorrhage. In ligaturing a wounded and bleeding artery, it should be remembered that both the upper and lower divisions should be separately secured, if the vessel has been completely divided; and that equally, if the division be incomplete, a ligature should be placed above and below the opening in the vessel. It is only in a case where from some cause or other the proceeding cannot be successfully accomplished, that ligature of the principal artery at a distance from the wound should be resorted to.

As, however, there are many cases of gunshot wounds accompanied with more or less bleeding, or liability to recurrence of bleeding, in which the application of ligatures is not advisable, or practicable, at the first lines of help, and in which the use of tourniquets has therefore to be resorted to, it may be useful to make some observations on these instruments, particularly in reference to their employment in the field.

Tourniquets for use in the field.—In civil practice various kinds of tourniquets and compressors have been devised for the temporary arrest of hæmorrhage; but most of them are too bulky, or too liable to get out of order, for the requirements of surgical practice in the open field, where portability and simplicity are of extreme importance in all appliances. In field surgery the tourniquets are usually limited to two kinds, which are sufficiently familiar to all surgeons, viz. the simple pad and strap, or *field tourniquet*; and the somewhat more complicated *screw*, or *Petit's tourniquet*. They are contained in the regulation cases of surgical instruments for use in the field supplied to most, probably to all, armies.

The old methods of restraining hæmorrhage by surrounding the limb with a handkerchief and stone in it, or with a band tightened by twisting it round by means of a sword or a stick of wood placed between it and the limb, and other like proceedings, though still occasionally recommended as simple contrivances for stopping bleeding, involve risks of hazardous consequences on field service; and their use, so far from being encouraged by army surgeons, should be deprecated as dangerous expedients, only to be resorted to under the most exceptional circumstances. A so-called 'improved elastic tourniquet' was introduced about two years ago with the same dangerous qualities.[3] Fortunately the pain caused by such proceedings under ordinary circumstances is so severe, that the ligature cannot be retained for any great length of time, without very earnest efforts being made to obtain its removal. Help is urgently called for, and thus, if a surgeon can be found, the threatened dangers are prevented.

The ordinary pad, buckle, and band, or 'field tourniquet,' is only a few degrees better than the contrivances above named. In whatever part of a limb a wound leading to hæmorrhage occurs, even if in the hand or foot, the pad and buckle tourniquet, when applied, is usually put on at its upper part, because the control of the bleeding is easier and more complete there than at any part below. To be effective it must be tightly applied, and with such constriction the circulation, both superficial and deep, is almost entirely stopped, the limb becomes numbed, and the contractile power of the muscles is weakened. General venous congestion and œdema of the whole limb below the seat of constriction are induced. Rapid deterioration of the condition of the tissues near the gunshot wound itself with its devitalised surface and torn vessels, clotting of the blood remaining in the surrounding vessels, and other mischief, follow. Throughout the whole limb a decline towards loss of vitality takes place according to the degree in which the circulation of blood and nervous energy are arrested, and the length of time the arrest is continued. Thus a very unfavourable condition is brought about for future surgical interference not only at the seat of injury, as for ligature of a vessel in the wound for example, but even for amputation should it be required, and for the subsequent repair of the stump in case of this latter operation being resorted to. Tourniquets once applied will often be retained for long periods under the circumstances of warfare; surgeons can rarely say how long. Where many men are wounded together, where a defeat followed by a pursuit causes a considerable extent of ground to be passed over by the combatants, or where fighting takes place among thickets in a wooded country, it must constantly happen that some men, who are disabled by their wounds from walking to get assistance, will remain many hours undiscovered and unattended to by the surgeons; and if a wounded limb

be left during this time compressed and strangulated by a tight tourniquet of the kind mentioned, gangrene will be the almost inevitable result. A soldier, even if he be able, notwithstanding the pain, will, under such circumstances, probably not dare to relax it himself from fear of death following from bleeding. Indeed the use of field tourniquets of the common forms has been stated to be followed by mortification and loss of limbs in such frequent instances, that the discontinuance of their employment has been strongly advocated in some quarters. Some American surgeons, owing to the ill results produced by them, have even expressed their conviction that, on the whole, it would be less hazardous to leave the wounded to nature, without using any mechanical appliance for arresting hæmorrhage, than to depend upon the common pad and buckle tourniquet.[4] The ill effects of these instruments were said to have been particularly noticed after some of the battles in the early periods of the late American civil war; and the same thing was stated after the great battles of Solferino and Königgratz, owing to the length of time which elapsed before surgical assistance was given to many of the wounded.

As tourniquets cannot, however, be discarded from use in field practice, it becomes important to consider how that which is objectionable in them can be most reduced in amount and effect. It may be accepted as a fact that it is impossible to avoid compressing the main vein at the same time that the main artery is compressed by any appliance under the circumstances in which such compression has to be exerted in field surgery; the surgeon may dismiss from his mind the expectation that any form of tourniquet will compress the one vessel without compressing the other, placed as they are together in the situations where field tourniquets have to be employed. The most we can hope to do, then, under such circumstances is, while making the necessary pressure to control the bleeding from the wound, to provide that the rest of the circulation of the limb shall be interfered with as little as possible—to contrive that a space shall be left free from compression, so as to allow circulation to go on through the collateral smaller vessels of that space unimpeded.

Several field tourniquets have been designed with a view to attain the advantages just described.

Lambert's elastic tourniquet.—A field tourniquet, to which the name of the *Elastic Tourniquet* has been given,[5] or, Lambert's New Field Tourniquet, as it was also called, from the name of the inventor, Dr. Lambert, was first brought to notice in the United States at the latter end of the year 1861. This tourniquet consists of two concave plates of polished metal, and of some elastic, as well as of some non-elastic, bandage. The two metal plates are of different sizes; the larger being nearly 3 inches in length by 2 inches in width; the smaller nearly 2 inches in both directions.

The non-elastic band, which is about 21 inches in length, and $1\frac{1}{2}$ in width, is employed to connect the two plates; the elastic band, which consists of a piece of India-rubber webbing about 1 inch in width and about 1 yard long, is buckled on to the end of the non-elastic band. The metal plates act as pads, and are used as the means of pressure to restrain the flow of blood; the smaller being placed over the artery, the latter on the side of the limb opposite to it, for counter-pressure. Each of the metal pads is furnished with a pair of projecting wings, made of thick iron wire, one at each end. The wings move on hinges, and fold

FIG. 28.

Lambert's Elastic Field Tourniquet.

completely down upon the pads in one direction, while in the other their movement is limited. When they are expanded to the utmost extent in this latter direction they stand out at such angles with the pads that, while they act as supports and as means of fixing the connecting bands, they also prevent the bands from being in contact with the limb which they encircle. The elastic webbing is intended to be passed completely round the tourniquet, and by being put on the stretch, to maintain additional pressure as occasion may require by its elasticity. The manner in which the instrument is applied is shown in the drawings placed above, which are taken from Dr. Lee's pamphlet on the subject.

The essential difference in principle between the elastic tourniquet and the ordinary pad and screw field tourniquets is the adoption of the wings for the purpose of limiting the compression to two parts of the limb, viz., to the immediate neighbourhood of the main artery, and to the part of the limb opposite where the counter-pressure is exerted. All the remainder of the limb is intended to be left free from any such pressure as will interfere with the general circulation through it. The importance of this provision has been already adverted to. Practical trials with this tourniquet have shown that it does answer its intended purposes, especially for the arm, and for the thigh also in moderately developed persons; but when a patient is very muscular the wings are not expanded enough to prevent all lateral constriction. The other advantages claimed for the elastic tourniquet are that it is simple in construction, portable, quickly and easily applied without assistance (often an important matter in field surgery), steady in position after application, and of inexpensive materials. The American elastic webbing was tested at Fort Pitt in 1862, with a view to ascertain the effect of tension upon it in a moist and tropical atmosphere, and, as far as the experiments went, it maintained its elasticity under such conditions well. At the same time it is necessary to remember that most vulcanised india-rubber materials obtained in England are found to undergo, after a certain time, molecular changes which materially impair their quality of elasticity, owing to the white lead and other chemical substances which enter into their composition.

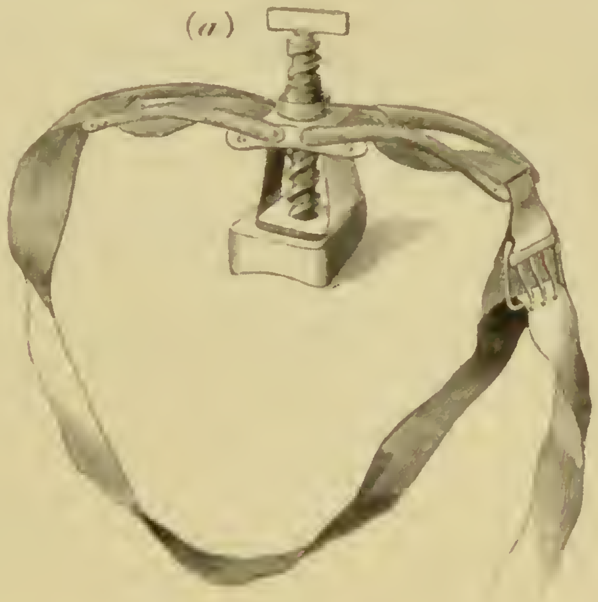
Mott's winged tourniquet.—During the war of the Rebellion in the United States a series of essays on surgical subjects were published for distribution to the medical officers of the army, and one of these was on 'Hæmorrhage from wounds and the best means of arresting it,' by the eminent Professor Valentine Mott, of New York. In this essay he described a tourniquet invented by his son, Dr. Alexander Mott, which he considered preferable to that of Dr. Lambert, as being more simple in construction, more compact, and more readily applied with one hand by a wounded soldier upon himself. It is composed of two steel plates. The anterior one, which is $5\frac{1}{2}$ inches long, has a wooden pad fixed transversely to its centre by two screws, and has its two ends curved upwards so as to form wings, at the end of each of which wings a buckle is secured. The posterior plate is of the same length and shape as the anterior one, and has but one point of pressure, viz., at the centre. A piece of webbing 12 inches long is riveted to each extremity of this plate. When applied to use the projecting ends of the two steel plates answer the same purpose as the wings in Lambert's tourniquet.[6] Although this instrument is certainly very simple and is free from the danger of constricting a limb, it was found, on trying it at Netley, to be liable to slip on one side when a patient moved

about, owing to its peculiar shape, and to the convexity of the wooden pad. It answered better for the thigh than for the arm. Its length and curved shape make it rather awkward for personal carriage.

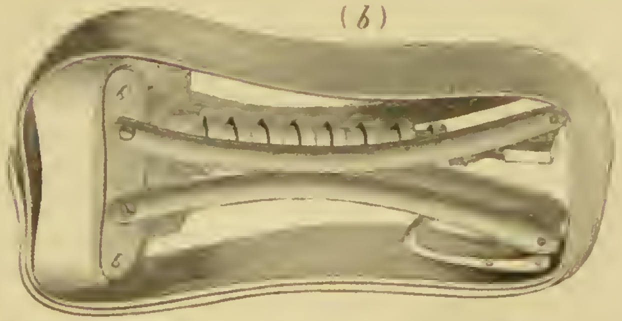
Winged screw tourniquet.—The screw, or Petit's tourniquet, which has long been used in military as well as in civil practice, possesses many advantages. It has great compressing power, and this power can be well regulated by means of the screw adjustment.

FIG. 29.

(a)



(b)



(a) Moffitt's winged screw tourniquet (open); (b) Moffit's winged screw tourniquet (folded up).

When the mechanism of the instrument is understood it is easily applied, but from being rather complicated it is liable to be disarranged in unskilful hands. The chief objection to it has, however, been the general constriction to which, in common with the ordinary field tourniquet, it subjects the limb from the direct

compression of the whole of its circumference by the strap. To prevent this, Surgeon-Major A. Moffitt applied wings to it somewhat similar to those attached to Lambert's winged tourniquet. The drawings show the instrument with the wings expanded, and also with them folded up. The wings, when open, stretch outwards to each side so as to give a space of $6\frac{1}{2}$ inches, an extent which exceeds the diameter of a thigh of average size. The compressing pad is made of wood $\frac{1}{2}$ inch thick, by 2 inches long and $1\frac{1}{2}$ inch broad, with its under surface concave.[7] The strap is permanently fixed to the upper surface of this pad. When folded up the instrument forms a package of $3\frac{3}{4}$ inches long, 2 inches broad, and $1\frac{3}{4}$ inches deep. It is thus sufficiently portable, and when compared with the Petit's tourniquet in ordinary use, will be found to be more simple in construction owing to the absence of the lower plate, and the strap being fixed in position. But its great advantage is that while it has the compressing power and capacity for adjustment of the unwinged tourniquet, it is free from the defect of constricting the whole limb which belonged to that appliance.

General distribution of tourniquets in armies.—The necessity for a general distribution of tourniquets among the combatants of an army on active service is so frequently urged by non-professional persons on the occasion of war, and sometimes, indeed, by surgeons,[8] in order that everyone may have the means of checking hæmorrhage always at hand, that it seems necessary to say a few words on this topic. Those who recommend this proceeding seem to think that every gunshot wound is accompanied with such an amount of loss of blood that life is endangered from this cause alone, whereas experience teaches us that it is only a limited proportion of the gunshot wounds occurring in battle which prove fatal from primary hæmorrhage. No one could reasonably admit the necessity for furnishing every soldier with a tourniquet to protect himself against the chance of his happening to form one of this proportionate number, even allowing that no impediments would exist to the application of the instrument in case of such a wound being received, without equally granting the necessity for providing every soldier with the means of warding off a number of other casualties to which he must be exposed in battle. And were such admissions to be acted upon, it is obvious that the soldier would be so encumbered as to hinder the execution of the very objects for which he has been trained and for which he is employed. But the most serious objection of all to such a general distribution of these instruments is that it would certainly be followed by a vast amount of positive mischief. Although gunshot wounds are comparatively rarely attended with hæmorrhage of a fatal character, almost every wound is attended with a certain limited loss of blood. By untrained and excited observers this bleeding would at once be

interpreted as an occasion for using a tourniquet, evils already mentioned would result, and thus in numerous instances a simple wound would be converted into a grave one. Others have advocated that the non-commissioned officers of each regiment should carry a certain number of tourniquets, after receiving some training in their application. It is very questionable whether this arrangement would effect any practical good, and, supposing some good might occasionally follow, whether the same might not be accomplished more surely by other means. It is not likely that the tourniquets carried by non-commissioned officers could ever be made use of during the progress of an action. How could these soldiers, without neglecting their more important duties in the combatant ranks, pay attention to a wounded neighbour, even if he were seen to be bleeding to death? How could they stop to get at the instruments, or to allow others to get at them, even if such attention were permissible? Now and then, as the movements of the troops vary, ground where wounded men have fallen may be left clear, and, as a certain proportion of the non-commissioned officers will be probably amongst them, these tourniquets, if required for particular cases by bearers or others, would then be within reach. Such cases, however, could scarcely ever happen; for the majority of those who have had large arteries opened in such a way as to lead to dangerous hæmorrhage while the fighting was going on, will have died as surely and almost as quickly as if they had been shot through the heart; while those who have had them otherwise divided, or who have bled from arteries of inferior importance, will be safe from further hæmorrhage by natural occlusion, unless they are subjected to injudicious violence at the time of reaction. Other circumstances will also no doubt occur during warfare, under which there may be no difficulties as regards time or occupation in getting at tourniquets carried by non-commissioned officers, and turning them to account in case of need. But how comparatively rare, again, these opportunities must be, if we exclude the occasions when the tourniquets carried specially by bearers and other hospital attendants for supplying such wants are equally available!

Digital pressure of bleeding vessels in wounds.—The majority of army surgeons altogether disapprove of such instruments, however perfect they may be in construction, being placed in the hands of combatants of any grade; and I agree with this opinion, because I believe the mischief done by them would be likely to exceed any good that might result from their possession of them. But even their employment by the bearers trained for carrying and helping the wounded has been opposed by some influential surgeons. It has been argued that it would be better to teach attendants, whose duty it is to carry wounded from fields of battle, to insert a finger into every wound from which they see hæmorrhage occurring, and to keep it in the wound during the transport until the aid of a

surgeon can be obtained, instead of instructing them in the application of tourniquets. The attendants will be perfectly able to stop the bleeding by direct pressure upon the open vessel, while the evils which occasionally result from the employment of tourniquets will be avoided. No doubt all that is required to carry out such a proceeding, is a certain amount of care and calmness, and there is no reason to suppose that these qualities will be found wanting after a proper comprehension of the nature and objects of the operation have been acquired; at least, not among men who are fitted to be hospital attendants, or bearers of wounded from a field of battle. The precise spot where the compression is required, and the degree of pressure necessary, will be quickly made manifest to sight, by the effect on the flow of blood. The practice of stopping hæmorrhage by means of a finger inserted into the wound, was said to have been resorted to in the Russian army during the Crimean war, and to have been practised with success. Tourniquets were scarcely ever used. The Russian surgeons trained soldiers and stretcher-carriers to put their fingers at once into wounds, and to exert pressure whenever much bleeding from them was observed. Dr. Demme, in his work 'Studies on Military Surgery in the Italian Hospitals in 1859,' mentions that several lives were saved by instructions to the same effect being given to men of the Austrian army in that campaign.[9]

As regards officers and soldiers in the ranks, it certainly seems less objectionable to inculcate the plan of stopping bleeding by pressure of the finger within the wound than to make a general issue of tourniquets to them; for their knowledge of the proper application of such instruments, whatever hints on their employment may be previously given, must always remain exceedingly limited. But there does not appear to be any sufficient reason why tourniquets should not be put into the hands of all trained bearers and hospital attendants. If properly trained they will understand what to do, and what to avoid, in applying the instruments; while the application of them will leave the hands of the men free for performing their work as bearers, or for doing other duties, which they would not be able to do, when engaged in stopping bleeding by digital pressure. In an urgent case, and in the absence of the necessary instrument, such men would of course understand the mode of stopping hæmorrhage by digital compression, whether within the wound itself or along the course of the artery leading to it.

Medicines at the dressing stations.—In respect to internal remedies, the only medicine likely to be required in the field, other than the ordinary stimulants and restoratives, is powdered opium or morphia. In many cases it is extremely advantageous to administer a dose of one or other of these preparations at the dressing station. An opiate will often be of use in cases of abdominal wounds, in wounds

accompanied with excessive pain, in others in which much bleeding has induced prostration, tendency to syncope, and nervous excitement, and in which the administration of alcoholic stimulants would involve risk of causing further hæmorrhage, and, perhaps, in some other instances. Morphia prepared in proper doses and arranged in small packets ready for use when required, should be at hand at every dressing station in the field.

Remarks on the index tablets, or 'tallies.'—As soon as the necessary attention has been given to a wound at an advanced dressing station, especially if any surgical operation has been performed, such as the ligature of an artery, or the extraction of a bullet, or if a dose of opium has been given, a statement, as brief as possible, of the nature of the wound, and of what has been done, should be written under the proper headings, on one of the 'tallies' provided for the purpose. The tally, when signed by the surgeon, should be carefully attached by one of the attendants to a button or some conspicuous part of the soldier's tunic. It should be remembered that the object of the tally, and of the information given on it, is to prevent needless re-examination of the wound, while the patient is on his way to the field-hospital or after he reaches it; as well as to direct the attention of the surgeon under whose care the wounded man may be placed on his arrival, to any circumstance which it may be important for him to be aware of in the interest of the patient, or as affecting the subsequent treatment of his wound. Three or four words will generally suffice to give the indications referred to, and the few moments spent in writing them will be fully repaid by time saved subsequently, as well as by the advantages resulting to the patients. The form of these field-tallies is described elsewhere, in the chapter on Field Equipment.

CHAPTER II.

GENERAL TREATMENT OF WOUNDED MEN ON THEIR ARRIVAL AT A FIELD-HOSPITAL.

HAVING considered in the preceding chapter the chief points to be noted in the preliminary treatment of gunshot wounds on the field of action, I now proceed to describe their further treatment as soon as the wounded men have arrived at a field-hospital. The name, regiment, regimental number, and general nature of the injury of each patient, as he is brought in, should be noted by some one deputed for this special duty; and, as soon as circumstances admit of its being done, a proper and complete diagnosis of his injury should be established, and its treatment systematically settled and commenced.

Arrangements according to the kind of accommodation at field hospitals.—Some of the arrangements for the custody and care of the wounded, and for the surgical management of their injuries, will necessarily vary according to the position and circumstances of a field-hospital and the accommodation afforded by it. If it be established at a farm or a country house at no great distance from the scene of action, it will soon become overcrowded; and some of the wounded, after having had their injuries attended to, will probably in a short time have to be removed further to the rear. Many of the wounded will have to be laid on the floors of rooms, in barns and outhouses, or under any shelter that may be available. If it be established in a village or town, better accommodation will be got, some bedsteads will probably be available, and more complete hospital arrangements can be established. If only a few bedsteads can be obtained, these should be reserved for cases of fractured limbs and for those in which amputations, or other grave operations, are performed. The difficulties in their treatment will be greatly enhanced if the patients are laid on the ground. In other cases temporary bedding should be provided by means of straw, hay, or any other convenient material, spread upon the floors. Some proceedings will have to be modified in proportion to the time the patients are likely to be able to remain in the field hospital. It will be useless to remove all the clothes of men who will have to leave the hospital beds within a few hours, or even within a day or two after their admission. If, on the contrary, there is a fair prospect of the patients being able to remain under treatment in the same place for several weeks, they will be placed systematically on their beds, will in turn have their clothes carefully removed, first from those parts of the body which are not injured, and next from those parts in which the fracture or other injury is situated; in short, the patients will be treated and placed as nearly as possible under the same conditions as they would be were they admitted for treatment in a fixed hospital. Other circumstances, which are noticed in the chapters on Transport of Wounded, Equipment of Field-Hospitals, and Field-Hospital Administration, will perforce modify the decisions of surgeons as to the proper treatment to be adopted in particular instances of gunshot wounds. The description of the hospital treatment of gunshot injuries, in this and in the following chapter, is only intended to afford information on the general plan to be followed, when, and so far as, circumstances admit of its application. In the practice of field-surgery, military surgeons are compelled to resort to all sorts of shifts to ensure the welfare of their patients, and these expedients must vary according to the peculiar conditions in which they find their patients placed at the time they require professional assistance.

Persistent shock.—Should a wounded man, on being removed from the stretcher on which he has been carried into the hospital,

be found to be still labouring under shock, and this shock is of an extreme character, it must not be forgotten that the condition of the patient is one of great hazard from this cause alone, and that special attention must be given to extricating him from it. All practicable efforts should be made to equalise the circulation, to restore warmth to the body, and to increase sensibility as speedily as possible, but at the same time very cautiously, and with no undue disturbance of the patient. Caution is required lest in trying to restore vital action the remedies applied may cause the reduced powers of the patient to be strained beyond endurance, and so the remedies themselves cause death. The heart that is scarcely acting, under excess of stimulation or disturbance, may cease to act altogether. The judgment of the surgeon will always be greatly taxed in severe cases of shock; not so much in respect to the nature of the remedies to be employed as in respect to the extent to which he can employ them with safety. His difficulties are increased when the shock arises from a wound in itself of extreme gravity, or when it is aggravated by collapse from hæmorrhage. When the last-named complication exists, the case becomes one in which the operation of transfusion of blood may be attended with benefit. In all cases of shock freedom from constriction of the surface of the body and the maintenance of a perfectly horizontal position are essential. Nature sufficiently indicates the necessity of this injunction. If the upper part of the body of a patient suffering from extreme shock be carelessly elevated, life will shortly be extinguished, for the heart will become overloaded and respiration cease. Artificial warmth should be applied to the body of the patient in any way most handy. Hot water in bottles to the legs, in tins to the abdomen, and wrapping in blankets may be employed for the purpose, at the same time fresh air should be freely admitted to the patient's face. If he can swallow, the administration of a little brandy by a spoon from time to time, sufficient to maintain the heart's action without exciting it unduly, is valuable, or, if deglutition cannot be performed, the administration of a stimulating enema. After a time, if consciousness of pain in the parts wounded be exhibited, or if any interest be taken in surrounding circumstances, these will be signs that the efforts to remove the effects of shock are being followed by success. As soon as this amount of improvement occurs, perhaps a little simple nourishment, such as beef essence, may be taken, and this will prove valuable as a further restorative. On no account should opium in any form be administered to a patient in a state of extreme shock or severe collapse; even a minute dose under such circumstances may lead to a fatal result. Nor should any surgical operation of a grave kind ever be undertaken before a patient labouring under extreme shock begins to rally from it, and exhibits some return of general and local sensibility. The wound itself,

however extensive and serious, provided it be free from hæmorrhage, calls less urgently under such circumstances for notice, than the general condition of the patient.

Temporarily arrested hæmorrhage.—If the surgeon finds that a wound has been plugged with lint, or that other means have been used for the control of hæmorrhage, and especially if the required notice is given of the dressings having been applied with this view at the dressing-station, while no complication has since occurred to call for special interference, the patient should be placed where he can remain quiet for some time, so that he may be disturbed as little as possible; at the same time, the treatment already adopted for securing closure of the divided vessels should be seconded by perfect rest of the injured part in a favourable posture, that is, one in which the structures involved in the wound are relieved from all strain, pressure, or call for action. The application of cold, and generally the administration of an opiate, may also be advantageously resorted to. On the next day, or before, if symptoms occur to indicate a need for the interference of the surgeon, the pressure may be relaxed, and if the tendency to bleeding appears to have been arrested, the ordinary treatment of the wound may be proceeded with. If the hæmorrhage recur, it will then have to be dealt with according to the situation of the source of the bleeding, and the particular circumstances of the case.

First hospital treatment of gunshot wounds in general.—But supposing that the patients brought in are free from each of the grave complications just mentioned, from intense shock and liability to active hæmorrhage; that any shock which is present exists only in a moderate degree; that, if weakened by exposure, pain, or the effects of a long transport in a jolting vehicle, some suitable restoratives have been administered; and presuming further that the nature of the injury is not sufficiently obvious without further examination; the following are the points to which the surgeon should give his attention as he visits the wounded in succession:—

1. Examination and exploration of the wound with a view to establish a definite knowledge of its nature, extent, and complications;

2. Removal of any foreign bodies which may have lodged;

3. Adjustment of lacerated structures, if the wound be of a kind to require it;

4. The application of the primary dressings.

The constitutional treatment, the proper kinds and quantities of nourishment to be administered, the successive local applications as a case of gunshot injury progresses through its successive stages, are matters for subsequent consideration.

It will be convenient to keep chiefly in view, first, the treat-

ment of such injuries as are caused by small projectiles, and afterwards of those resulting from heavy projectiles.

In order that a wound may be satisfactorily examined, it must be fully exposed, and any temporary dressings that may have been applied hastily on the field, gently removed, and any dust or dirt that may have become collected in its neighbourhood carefully cleared away. If the wound be on the head or on a part of the body covered with hair, this should be removed from its neighbourhood. When the injured part is quite clean and the wound itself free, the nature and extent of the injury inflicted should be accurately established.

Early diagnosis very important.—As complete a diagnosis as practicable should be established at the earliest opportunity after the arrival of a patient at a field-hospital. The importance of complying with this precept cannot be overrated. An examination of the wound can be made with less suffering to the patient and more satisfactorily to the surgeon at that time than at any later period. The sensibility of the parts adjoining the track of the missile is to a certain extent numbed before reaction is established; and there is less swelling to interfere with the examination, so that the amount of disturbance effected among the several structures, as well as the lodgement of any foreign bodies among them, are more obviously apparent than they will be subsequently. Moreover, the examination, if judiciously conducted, is at this period free from deleterious effects; while the same proceeding, if it be put into practice after inflammatory action has set in, is positively injurious, and even liable to prove dangerous in its consequences. It is the time, too, when the patient will generally submit to a thorough examination with the most readiness; his courage has not yet been lessened by protracted pain and confinement, while natural anxiety to learn his fate, or to ascertain the extent of the accident which has befallen him, stimulates him to support any pain that may accompany the ordeal.

It may be well to observe, by way of caution, that whatever conclusion a surgeon may come to in his own mind respecting the nature and extent of an injury at the first examination, it is always prudent to avoid making a positive statement on the subject to the patient or his friends, unless the wound be one in which the limits of the mischief done by the projectile are quite obvious to touch or sight. In no class of injuries is there greater liability to mistakes in diagnosis and prognosis than in gunshot injuries. It is impossible for a surgeon not to form an opinion regarding the nature of a wound as soon as the patient and the wound are exposed to his view; but, if experienced, he will be so aware what deeply seated mischief may exist though unsuspected, what complications without direct and immediate manifestation of their

effects, that he will always be on his guard about giving expression to a decided opinion in any case open at all to doubt. Such hesitation will not be likely to have any hurtful effect on the mind of the patient, although the latter may be most anxious to learn what will be the issue of his wound—and in a wounded man this anxiety always exists when his wound is first seen by a surgeon; he will rather appreciate a cautious opinion on the part of the surgeon at its proper value, and probably be impressed with more reliance on his judgment and ability than if he had received a positive statement as to his case, after an obviously hurried and inconsiderate, or unavoidably incomplete, examination. If there be sufficient ground after due observation for removing a patient's apprehensions, it ought to be done by all means; but if any source of uncertainty exists, the opinion given ought always to be a guarded one, notwithstanding the temptation to make an absolute declaration on the subject. I have known unpleasant results happen from want of caution in this respect.

It is on these accounts that the first examination of each patient, and the diagnosis of his injury, should be made in succession by the senior surgeon in charge of the field-hospital, or by a responsible surgeon in whom he has full confidence told off for the duty. When the diagnosis has been properly established, if the injury has been found to be a simple one, or if any complications that may have accompanied it have been attended to and rectified, the patient may safely be handed over to one of the junior surgeons, or to one of the trained attendants, for the application of the established dressings; if, however, the case be a complicated one or require special attention, the necessity for its treatment only by an experienced surgeon will be sufficiently apparent. The applications for relief at the field-hospitals after an action are generally very numerous and pressing, and a systematic plan of conduct is essential, in order that the surgical disposal of the patients may be expeditiously managed, and at the same time accomplished satisfactorily from a professional point of view.

Mode of examining gunshot wounds.—One of the oldest rules for examining a wound, in which a bullet or other projectile of limited size has penetrated and passed out of sight, is to place the patient in a position, as nearly as can be ascertained, similar to that in which he was in relation to the missile, at the time he was struck by it. This rule is as valuable now as it was found to be centuries ago; perhaps even more so, since modern rifle projectiles are so much less liable to be deflected by accidental circumstances from a definite line of direction than the bullets employed in former days.[10] In almost every instance in which the rule can be carried out without inconvenience to the wounded man, the diagnosis, and conclusions in respect to the necessary treatment, will be facilitated by attention to it. Occasionally, when a projectile has

lodged, it will lead to the immediate discovery of the place of lodgement; or if it has made its escape, it may be the means of indicating the probability of injury to the surface of a bone, to a joint or other important structures, in cases where the mutual relations of the wounds of entrance and exit would lead to no such information, or in which the altered position and relation of tendons and muscles overlying the deeper sites of injury would prevent the information from being obtained in either the erect or horizontal posture of the body. The course the projectile has taken may be one in which an important blood-vessel can scarcely have escaped from contusion, leading to the liability of secondary hæmorrhage, or gangrene; a complication which may not be suspected, or at least may be overlooked without sufficient circumspection in respect to the above-named rule, on the first admission of a patient into hospital.

A surgeon has only to observe the variety of attitudes in which men place themselves when advancing as skirmishers against a supposed enemy—to watch them creeping along the ground, lying prone under some slight cover while firing, and assuming other similar attitudes in order to obtain as much shelter and protection as practicable in exposed situations—and then to consider the probable courses that bullets discharged by an enemy in front, and striking these men in various exposed parts of their limbs or bodies would take, in order to understand how impossible it would be to explain the direction of wounds produced under such circumstances without knowing the positions the patients were in at the time they received their injuries. It will be equally evident how little a surgeon, without the same knowledge, may be able to form an opinion of the injury done by a projectile which has entered without passing out again; how little the position of the single opening can guide him to a knowledge of the course taken by the bullet.

Even in cases where the condition of the patient, or the nature of his wounds, renders it impracticable to place him in the same posture in which he was when he was wounded, the inquiry should always be made as to what that posture was. If a correct reply can be obtained, the anatomist may then judge what would be the probable course of the bullet, and will be able to form a better opinion as to the particular structures it may have damaged in its passage.

Examination of clothes.—Whether one or two openings have been left by the projectile, the uniform and underclothes of the patient should be examined at the time they are taken off whenever circumstances permit; the inspection of the uniform or accoutrements worn over the part wounded, as previously explained, will often serve as a guide in determining whether foreign bodies have entered or not, and, if so, their kind, and, to some extent

perhaps, their direction. Time may thus be saved, as well as pain avoided, in the examination of the wound itself.

The examination of the clothes having been made, and very little time need be occupied in making it, particular attention should next be turned to the wound itself.

Exploration of a gunshot wound.—Two objects are to be kept in view in examining the wound. One is the establishment of a correct diagnosis as to its limits and to its nature—whether it is simple in character, or accompanied with injury to bone or other important structures; the other is to determine if the injury be complicated with the lodgement of the projectile by which it has been inflicted, or of any other foreign bodies carried in by it. If the wound be one in which there is no ground for suspecting injury to bone or other structures of prime importance, if the wound, in other words, seem to be a simple flesh wound, the examination will be made chiefly to determine the question of lodgement; but still, at the same time, we should always definitely establish the fact that the wound is the simple one we suppose it to be. As both the points at issue, the extent and nature of the wound in respect to the existence of special structural complications, and the question of lodgement of foreign bodies, ought to be solved by one and the same examination, I shall consider these two objects of the exploration of a gunshot wound together.

When only one opening has been made by a projectile, it is to be presumed that it is lodged somewhere in the wound, and search must be made for it accordingly. The only exception is when it is known that it has escaped from the wound of entrance—a rare occurrence—during the movement of the patient on his way to the hospital. But even where two openings exist, and evidence is afforded that these are the apertures of entrance and exit of the projectile itself, the examination should still be made unless the case is one that admits of no doubt as to its nature and freedom from complications. In any case admitting doubt, the examination is made both to determine the extent and nature of the wound with accuracy, and also to detect the presence of other foreign bodies exclusive of the missile itself; especially when the appearance of the clothing, or of other articles, has indicated that portions have been detached from them.

The foregoing, as well as the subsequent, remarks on the extraction of foreign bodies from wounds, only apply to the cases in which the patients are brought to the field-hospitals within a few hours after their wounds have been inflicted, before inflammation has occurred. If from any cause the admission of the patient has been so long deferred that the seat of injury has become swollen and inflamed, even though the surgeon may be told that a bullet is lodged in the wound, it is better to delay the exploration until suppuration becomes established. The only exception to

this rule should be a case where the foreign body is so superficially lodged that it can be removed at once without any difficulty. To make a search among parts in a condition of active inflammation would not only be a difficult proceeding on account of the swollen state of the tissues, but would cause great pain, aggravate the existing inflammation, and not improbably give rise to an amount of nerve-irritation, the effects of which might afterwards prove to be beyond control. My colleague, Professor Maclean, as I have before mentioned, saw a series of cases of tetanus occur among some wounded soldiers in China; and in all these instances the wounds had been explored while they were in the first stage of inflammatory excitement.

Exploration by the surgeon's finger.—Of all instruments for making a complete examination of a gunshot wound as well as for exploring for foreign bodies which may be lodged in it, the finger of the surgeon is the most appropriate, whenever a wound is large enough to admit of its insertion. By its means the direction and limits of the wound, as well when it is devious as when it is direct, can be ascertained with least disturbance to the several structures through which it takes its course, and the true condition of the injured structures most thoroughly noted. If there be an obstruction to the progress of the finger, and it arises from a tendon which has come into the line of the track of the bullet, or from a layer of tendinous aponeurosis or from any similar barrier, the nature of the impediment can be felt, and it can be moved aside or otherwise avoided. If bones are fractured, the number, shape, length, position, and degree of looseness of the fragments may be more readily observed. If a bone has been grazed and denuded of its periosteum, or if a bullet has been flattened and become impacted superficially on a bone, the sensation of a finger will communicate information of what has occurred. Exploration by a finger will establish the fact of a joint being opened and the bones damaged in some cases where, if a probe had been used instead, the injury to the articulation would have remained a matter of doubt. When foreign bodies are lodged among the soft tissues, not only is their presence more obvious to the finger direct than through the agency of a probe or other metallic instrument, but by its means intelligence of their qualities is also communicated. A piece of cloth lying in a wound is recognised at once by a finger; while, saturated with clot as it is under such circumstances, it will probably be mistaken for some of the natural soft parts by any other mode of examination, and be left undiscovered. The index finger naturally occurs as the most convenient in this employment; but the opening through the skin, and, more especially, that through the fascia, made by a modern rifle ball of small diameter when it has entered in a direct line, or one by a pistol ball, is generally too small, or, from having become swollen, is too contracted, to admit of its

free entrance. In such a case the finger should not be thrust in with undue force, which is hurtful in many respects, but an incision to the necessary extent should be made at the margin of the opening extending through the fascia, to faciliate its ingress; or the substitution of the little finger will perhaps answer all the purposes intended, without having recourse to any cutting whatever. An incision, however, can rarely be productive of any harm if judiciously made; on the contrary, may often prove very useful in opening readier means of escape for the discharges, and especially in facilitating the extraction of a foreign body should one be discovered in the wound. When the finger after insertion fails to reach sufficiently far, owing to the depth of the wound, the examination for foreign bodies is often facilitated by pressing the soft parts, especially if the wound be in one of the extremities, from an opposite direction towards the finger end. The finger, in making the exploration, should be inserted slowly and steadily towards the deepest part of the wound. During its passage the surgeon should carefully observe whether any foreign body appears to be pushed before it, or to be lying by the side of the track of the bullet, and should note any other peculiarities of the wound. He should also ascertain whether the end of the track is reached; and if this is found to have been arrived at, a careful rotatory movement of the finger, with a circular sweep of its extremity, will then usually determine if any, and what, foreign bodies are lodged. The surgeon should not withdraw his finger until the course the projectile has taken, the injury it has done, the complications of the wound, such as the presence of foreign bodies, and, in such a case, their kind and situation, have been settled in his mind; the exploration will thus be completed by one operation, and a second insertion of the finger for the purpose, which is always irritating to a patient, will be avoided. Nothing can be simpler than the exploration of a gunshot wound by the finger, yet, simple as it is, very different results may follow the operation according to the manner in which it is performed; if done carelessly and impulsively, it will be done roughly, will cause proportionate bruising, pain, and, after all, convey only imperfect information; if done thoughtfully, these hurtful effects will be avoided, while the knowledge conveyed by the manipulation to the surgeon will be definite, and generally of special utility in determining the proceedings to be afterwards adopted.

Exploration by a probe.—If the finger be not sufficiently long to reach the bottom of the wound, even when the soft parts have been made to approximate by pressure from an opposite direction, and when the lodgement of a projectile is still suspected, or some other point of doubt remains to be solved, such as the direction the projectile has taken in the latter part of its course, the surgeon is compelled to make his further exploration by other means.

Under ordinary circumstances a long silver probe, that admits of being bent by the hand if required, and that can be guided into a definite direction at the will of the surgeon, is perhaps the best substitute for the finger. Elastic bougies or catheters are apt to become curled among the soft parts, and do not convey to the sense of touch the same amount of information as metallic instruments do. The probe should be employed with great discretion, for without care it may readily inflict injury to a joint capsule, to vessels, or other structures which have escaped from direct contact with the bullet, and have returned by their elasticity to the situations from which they had been pushed or drawn aside during its passage. These directions for examining wounds apply only to such as penetrate the extremities or extend superficially in other parts of the body; when a missile has entered any of the important cavities, exploration of the kind named would be useless as well as mischievous.

Neglect of early exploration of wounds.—This is not the place to describe the points to be attended to in establishing an exact diagnosis of particular injuries; these can only be properly considered when the wounds of special regions are studied. What I have most wished to call attention to is the necessity of making the digital examination of a wound in all cases where it is practicable to do so, and of forming a diagnosis, as complete as possible, at the earliest opportunity a surgeon has of doing so.

It may appear that I have dwelt unnecessarily long, in the remarks above made, on this subject, and have exaggerated its importance. But the military surgeon's experience in general hospitals shows how frequently these rules, so simple, are neglected; and, moreover, at the same time serves to prove how much the results of treatment of an injury, and how much, as a consequence, the health and comfort, nay, even the life of a patient, may depend on their having been attended to or neglected. It not unfrequently happens that wounded soldiers, after receiving their primary dressings at a field-hospital, are compelled by circumstances to be sent on the same day, or the day after the action in which they have been wounded, to general hospitals far in rear of the scene of conflict. Two or three days may be occupied in the transport. Under such circumstances, by the time the patients reach the general hospitals, the opportunity of making the digital examination is gone; inflammation, swelling, excessive sensitiveness in the neighbourhood of the wound, as well as a general condition of constitutional irritation, have supervened; and the exploration, which could have been readily made and easily borne on the field, is no longer practicable. The diagnosis must now remain uncertain until some time has elapsed; most probably until suppuration has become fully established. The injury may be one in which to have rendered the wounded part as immovable as possible, an opened joint for

example, was of essential importance; or one for which a primary amputation, resection, or other surgical operation would have offered the best hope of safety to the patient; but, under the circumstances I have named, the time when the precautionary measures would have been of most value has been lost, and the opportunity of performing the primary operation has gone by. Foreign substances, increasing the local irritation, may be lying among the injured structures, but there they must remain until a more advanced condition of the wound admits of their being searched for, and, if then found, of being removed.[11]

Special modes of exploring wounds.—In a large proportion of cases of gunshot wounds there will be no difficulty in detecting the lodgement of foreign bodies, especially heavy ones, as musket bullets, when the examination has been made early by the finger in the way I have already described. If a bullet, which there is good reason for believing has lodged, cannot be discovered in the immediate neighbourhood of the apparent limits of the wound, it should not be forgotten that such projectiles are occasionally diverted to long distances. The sensations of the patient should be consulted particularly in these cases, and observation should be made to detect any irregular elevation of the surface, or deviation from the natural contour of the parts, where there is a probability of the foreign body having become lodged. Sometimes, when the usual means have failed to find a lodged bullet, the particular place where it is lying may be detected simply by relaxing the muscular tissues, so as to give a loose and pendulous condition to the parts concerned, and then lightly tossing up the flesh at different points from below with the tips of the fingers. The bullet, if lodged among the soft parts, will occasionally make its presence known, under this action, by the impulse which its weight communicates to the top of one of the fingers, when the parts which have been shaken upwards return to their previous position. Sometimes a gentle kneading pressure in the neighbourhood of the injury, assisted by information derived from the sensations of the patient, will lead to the detection of such a foreign body. Sometimes, as mentioned in the English official history of the Crimean war, when a lodged bullet could not otherwise be discovered, it was found by passing the flat palm of the hand down the limb. It was occasionally detected in this way when the points of the fingers had utterly failed in feeling it. In certain particular cases, however, difficulties arise in settling questions of suspected lodgement that cannot be overcome by such simple plans, and then other special means have to be resorted to for solving them. These cases will be considered when the exploring instruments which have been specially invented for the purpose are described.

General rules for extracting foreign bodies from wounds.—As soon as the presence of a bullet, or of any other foreign body, is

ascertained, whether it be among muscular tissues or in bone, it may be laid down as a general rule that it is to be removed as speedily as possible, by the most easy and direct route.

Every reasonable effort should be made to extract foreign bodies lodging in wounds on their first coming under a surgeon's care. The surgeon should follow this rule, because, in a large proportion of cases, it is easier to remove them at this early period than it is at a later time; because, in the large majority of instances, lodged foreign bodies, as has been particularly shown elsewhere, lead to much suffering, and sometimes to disastrous consequences, while it is only in exceptional cases that they remain lodged in the human frame with impunity; and because, even though they may happen to be brought away naturally during the progress of cure of the wound, this only happens at the expense of protracted suppuration, and at the risk of various complications arising, all of which will be avoided if the surgeon succeeds in effecting the removal of the lodged sources of irritation at the outset of the treatment. Some few surgeons of eminence have opposed this general principle of treatment, as they have done that of the early exploration of wounds. They have considered that harm results from the efforts to extract foreign bodies unless they are lying plainly exposed to view: while, if they are left alone, they will either make their way out of themselves without inconvenience during the process of suppuration, or, if this mode of escape should fail, will remain lodged without causing much, if any, inconvenience to the patient. General experience does not, however, confirm these statements. Most surgeons are convinced that the advantages of early extraction of foreign bodies outweigh any disadvantages of the operation for extraction, provided the operation be judiciously performed.

Of course the rule of immediate extraction is to be applied within reasonable limits. It is not intended that it should be acted upon irrespective of other considerations. If the foreign bodies are lying in situations adjoining important cavities among large vessels or nerves, and it becomes a question whether the operation of extraction may not inflict mischief, either by injuring anatomical structures or by forcing the foreign bodies into the adjoining cavities, it had better be desisted from. But even here the very fact of a foreign body being in such a situation is all the more reason for its removal from it; and it really is more a question regarding the anatomical knowledge and operative skill of the surgeon, than of the propriety of the extraction of the foreign body. Again, a bullet may be lying in such a situation that from its depth, or from the tortuous course it has taken it cannot be extracted by the opening of entrance, while either the time or circumstances may render a cutting operation for its removal unadvisable. These, however, are exceptional occurrences, which must

be taken into account when the particular cases concerned fall under the notice of a surgeon; they do not destroy the propriety of the general rule for the immediate extraction of lodged foreign bodies, when wounds with such complications are first brought to the notice of surgeons at field hospitals.

There can only be one reasonable source of doubt in respect to the extraction of foreign bodies, but this is not so much a question as to the propriety of their immediate extraction where it is practicable, as to the particular time when, in cases of difficulty, the attempts at extraction should be desisted from. Instances will occur in which the surgeon will meet with reiterated failures in attempting to extract a foreign body, when the fatigue and pain of the operation begin to exhaust the patient's power of endurance, when the repeated attempts at extraction are perhaps beginning to cause injury to the parts concerned in the track of the projectile, and when, therefore, reasonable caution dictates that the efforts should be desisted from. No rule can be given as to the precise period when the attempts at extraction should be stopped in such instances. The time will vary with the circumstances of each case, and also with the operative skill and dexterity of the surgeon. A wise surgeon will of his own accord see when the time has come at which the dictates of prudence call upon him to stop further attempts at extraction.

Manipulation for extraction of foreign bodies.—If the foreign body be lying within reach by the wound of entrance, it should be extracted through this opening by an appropriate instrument. The ordinary dressing forceps will in many cases suffice for extracting the foreign body when it is near the opening, or the forefinger of the surgeon, either alone or together with a steel director, will equally answer the purpose. If the situation of the foreign body be deep, the extraction should be made by some one of the regular bullet-extractors described further on, and the operation conducted with more caution and skill.

The operation of extracting a bullet lodged superficially, or in muscular tissues near to the surface, is an easy matter enough. But when lodged deeply, it often requires more adroitness and patience than a theoretical consideration of the nature of the task to be performed would lead a surgeon to anticipate. The ease with which such a foreign body, when it retains its original shape, eludes the attempts made to grasp it, and slips aside into the soft tissues among which it is lying; the frequency with which some of these mobile tissues present themselves to the instrument and impede the prehension of the bullet itself; the frequency with which bullets, after they have become deformed, as well as all foreign bodies of jagged and irregular outlines, are caught and held firmly by some of the surrounding tissues; or, where bones are concerned, are wedged between them, or impacted in their sub-

stance; these are circumstances which form common sources of difficulty in the way of their extraction. Moreover, a recollection of the sinuous and irregular directions of the tracks made by projectiles of all kinds through muscular parts of the body; of the varied forms and dimensions of the openings left by them in different anatomical structures, especially the slit-like openings frequently met with in fascial and muscular aponeuroses; of the ease with which parts of the soft tissues may be pushed in front of an unyielding instrument; together with the tendency of the perforated structures to alter their relative positions before inflammatory adhesions have occurred among them, will further explain some of the impediments which are not unlikely to be encountered in attempts to grasp deeply-lodged foreign bodies, or to withdraw them from their places of lodgement after they have been grasped. When foreign bodies have been lodged for lengthened periods, other obstacles arise in the way of their extraction, but these are not met with in recent wounds.

Most English surgeons employ for the extraction of small projectiles a two-bladed forceps, or the instrument known in England as 'Coxeter's bullet-extractor,' and follow the rule of removing them by the shortest and surest channel. The forceps is the contrivance most generally applicable for the purpose, though Coxeter's extractor has the advantage of distending the track less, as will be explained in the description of the instrument. Whichever be used, it will generally be found necessary to enlarge the opening of entrance of the projectile by incision, if this has not been already done for facilitating the exploration of the wound. The opening in the fascia will particularly require to be dilated. If the track of the bullet be very narrow it may be essential to incise it also, but in the greater number of instances this will not be found necessary. The finger should then be inserted alone and the position of the bullet thoroughly recognised, and while the end of the finger remains in contact with it, the instrument should be passed along the wound by the side of the finger which serves as a guide. The blades of the forceps should now be opened, and the bullet fixed between them, the finger nail being used for the purpose of pushing aside any soft tissue that might otherwise be caught between either blade and the bullet. The same manœuvre should be performed by the end of the finger in gradually clearing the way for the scoop of Coxeter's extractor, to get behind the bullet, and afterwards in securing it in position by the points of the stem of the instrument. Deliberate effort should be made to get a firm hold of the bullet before any further proceeding is attempted. As soon as the bullet is felt to be well secured by either instrument, the finger is slowly withdrawn, and then by careful and steady manipulation to prevent the bullet, especially if it be altered in shape, from being caught by some of the tissues through which the

instrument holding it has to pass, or from catching others of importance, as vessels and nerves, which may be lying by the side of the track, the foreign body should be gradually extracted. In wounds where there is not space enough to admit both the finger and the extractor, the instrument can only be inserted after the finger is withdrawn, but the operation is seldom so quickly or so satisfactorily performed as it is when the finger can be employed as a guide to the passage of the instrument, and as a means of determining that the bullet alone is grasped by it. When a forceps is employed there is always the liability of some of the soft tissues being included in the triangular space bounded by the two arms of the forceps and the projectile which is grasped by its blades, and, if so included, it is not possible to extract the projectile without the tissue being torn asunder. When the forefinger can be inserted into the wound in addition to the forceps, this accident can readily be prevented, and the blades cleared from all beside the foreign body to be removed.

In any case when the insertion of the finger has not been admissible, and the character of the resistance offered to the withdrawal of the projectile is such as to lead to a suspicion that something else has been grasped with it, the attempt to draw out the instrument should not be continued. The blades of the forceps should rather be opened, the bullet set free, and another grasp made; or the instrument should be withdrawn altogether, and a fresh exploration made by the finger with a view to clearing away any tissue that may be lying across the projectile.

Especial care should be taken not to extract a soft foreign body such as a piece of cloth, or linen, from a deep situation roughly or with haste, lest by accident some of the natural soft tissues may have been seized instead of it, or with it. When using traction, notice should be taken whether pain is caused as the traction is made, and whether the substance grasped is free, or resists quitting its place of lodgement. In the latter case, the operation of extraction should be stopped, and a proper exploration be made before it is resumed.

One not uncommon impediment in the way of the extraction of bullets, especially such as have become distorted in form, and of all hard irregularly shaped foreign bodies, is the entanglement or actual interlinking of fibres of cellular and other tissues with the small rugged inequalities of their surfaces and edges, which took place at the time of their penetration. These small projectiles seem sometimes to act in the same way as barbed hooks would, and hold the fibres so tightly that they cannot be disentangled by simple change of position, but must be divided before the separation can be effected. If the finger can reach the projectile, such fibres may often be detached or scraped across by the finger nail, but whenever the foreign body is within convenient reach for the

purpose, it is both an easier and quicker proceeding to divide them by the edge of a knife.

In the days when spherical bullets were the foreign bodies which had chiefly to be removed from wounds, no attention was necessary as to the direction in which the projectile was to be withdrawn; so long as a hold of it was secured, there was little else to be considered; but with an elongated projectile unaltered in shape, it becomes important that the removal should be effected with its long axis in line with the course of the wound. To grasp a bullet upwards of an inch in length in the contrary direction could only be done by an unjustifiable separation of the blades of the forceps, and stretching of the walls of the contused track forming the wound. If the instrument be one of Coxeter's bullet-extractors, care should be taken that the long axis of the projectile corresponds with the long axis of the scoop. The same care should be exercised by the surgeon in withdrawing slugs, fragments of shell, stones, and all other such unyielding and irregularly-shaped bodies, from the bottom of wounds; the walls of which, it is to be remembered, are in a condition highly susceptible to further injury, owing to the severe contusion to which they have previously been subjected.

If the projectile be impacted in bone, in some of the bones of the foot, or in any situation where the fact of the lodgement can be fully established, the depth to which it has sunk into the substance of the bone should be noted, and the means for removing it determined according to its state in this respect. If it be sticking only superficially, it can usually, after freely exposing it to view by suitable incisions, be readily detached by an elevator. If it be deeply sunk, the elevator cannot be brought to bear upon it, and neither the forceps nor Coxeter's extractor will usually afford any help. If a tirefond screw be available, it will sometimes suffice to effect the desired extraction; but if this instrument cannot be obtained, some thin layers of the contused bone immediately surrounding the projectile should be gouged away, so that less opposition may be offered by the surrounding bone to its escape. An elevator, or common dressing forceps, will then generally accomplish the removal. In other cases, as when projectiles are firmly fixed in the shafts of bones, or have sunk to some depth in thin spongy extremities, the only means of removing them will be by the same operative proceedings which a surgeon would have to adopt for the removal of a necrosed sequestrum similarly placed. I believe these cases to be rare, however, with modern projectiles.

Removal of foreign bodies by incision.—In the cases above considered the object has been supposed to be to effect the extraction of the foreign body by the path along which it travelled to its resting place. But if the lodged bullet, or other foreign body, cannot be reached by the wound of entrance, but can be felt lodged in the flesh at some part distant from it; or if any circum-

stances exist contraindicating its extraction by the wound of entrance, such as its having got a site beneath structures which there would be risk of injuring, or which would have to be divided in order that the foreign body might be laid hold of; or if, having just stopped short of completely perforating a limb, it is felt lying beneath the skin, or not far from the surface at some point opposite to, or at a distance away from, that where it entered; in all these and similar cases an incision should be made for its extraction. Such counter-openings often have the additional advantage of assisting the cure of the wound by facilitating the escape from it of sloughs and purulent secretions.

The extraction of a lodged bullet by incision may also be advantageous for other reasons. A bullet may be firmly in the grasp of an extricating instrument, but an unjustifiable amount of force would have to be used for effecting its removal in a particular direction. It may be lying so far from the opening through which the instrument has been passed, that the finger may not be able to reach it, and the nature of the impediment to its withdrawal may thus remain unknown, or, at best, only be a matter of surmise. When such a difficulty arises, the surgeon will act wisely in not trying to overcome it by excessive force. After various movements have been resorted to with a view to disengaging it from the obstacles which are barring the way to its removal, and have failed, a fresh incision, so that it may be reached by some more direct route, if it be in a favourable position for such means of access, will be the best course to adopt. The following example affords a lesson on the importance of this injunction; for, owing to the changed form of the bullet and the situation in which it had become placed, no efforts for extraction, short of rending asunder the tissues in which it was engaged, could have succeeded in effecting its removal in the particular direction at first tried. In all such cases of difficult extraction, as in others of unsuccessful exploration of gunshot wounds before adverted to, no absolute rule can be laid down for guidance as to the time when the operative proceedings should cease; the tact and judgment of the operator must be relied upon to decide when the limit of justifiable effort for the extraction of a deeply lodged and firmly grasped foreign body has been attained.

A soldier was wounded in the shoulder in New Zealand, in November 1863, and resection of the head of the humerus was performed. The bullet was sought for, but not found. Nine months afterwards, when the patient was in hospital at Netley, search for the ball was again made. A sinus still existed, the orifice of which was on the inner wall of the chest, two inches below the apex of the axillary space. A probe passed along this sinus took a direction towards the inferior angle of the scapula. Efforts were therefore made in this direction for the discovery of the pro-

jectile; and, after a time, a probe came in contact with it, lying beneath the scapula on its pectoral aspect, and at a short distance above its inferior angle. A scale of lead was at first brought away by the bullet forceps along the sinus. The bullet itself was then grasped and a firm hold got of it, but it could not be extracted. Several kinds of extractors were employed, but with no success; the bullet appeared to be brought forward for a limited distance, and then to meet with some obstacle, which could not be overcome, without using an unjustifiable amount of violence. The attempts at withdrawing it by the sinus were now abandoned. An incision was made immediately below the lower angle of the scapula, and then, by passing the finger upward, with a little manipulation the projectile was removed. The difficulty which had been previously experienced was at once explained. The bullet, a rifle projectile, had been greatly altered in form. One portion was flattened and spread out like an extended wing, being prolonged for nearly three-quarters of an inch from the main part, and this portion had become fixed between the subscapularis muscle and the bone. The lead surrounding the hollow base of the projectile was marked with the indentations of the forceps, by which it had been grasped in the unsuccessful attempts at withdrawing it through the axillary opening. It was now sufficiently evident that it would have been better if these attempts had not been made, and if the incision at the inferior angle of the scapula had been adopted at once, as soon as the site of lodgement had been discovered; but the circumstance of the bullet being so firmly grasped by the forceps through the opening already existing, naturally led to attemps at taking it out in that direction. It was fortunate, however, that the traction on the bullet by the forceps through the existing opening was not continued with excess of force: the bullet could only have been withdrawn in that direction by tearing through the muscle, or by breaking off the flattened portion of the lead and leaving it behind.

Experience has sufficiently shown that it may not be out of place to mention, by way of caution, that the incision for extracting a bullet should not be made hurriedly, without sufficiently exact knowledge that the substance one is about to extract is really the foreign body it is suspected to be. Mistakes on this point have not been unfrequent under the excitement of field practice. An unnecessary incision was made near the outer malleolus of Garibaldi's foot on the scene of action, when no foreign body existed there. In the hurry of the moment either the external malleolus itself, or the elevation of the cuboid near its articulation with the os calcis, was mistaken for the bullet, which was really lodged elsewhere. Surgeon De Lisle, of the 14th Regiment, has related a case in which the supra-orbital ridge had been fractured, and a portion driven downwards towards the upper eyelid by a projectile. The displaced fragment was mistaken for a bullet, and cut down

upon with a view to its extraction, by a medical officer in the trenches before Sebastopol. In both of these cases a more thorough examination would have prevented the error. Dr. Stromeyer has recorded his having seen the outer prominence of the head of the fibula cut down upon under the impression that it was a lodged bullet, in a case where the bullet had already made its exit. This opening had been overlooked. He has also mentioned another case in which the head of the second metatarsal bone was mistaken for a bullet, and an incision for its extraction made through the sole of the foot. In this case, which terminated fatally, the error was all the more inexcusable, as an examination of the patient's boot would have shown that the projectile which had inflicted the wound on the front part of the foot had not even succeeded in piercing the leather. Other similar instances might be quoted, not only occurring in the field, where the circumstances in which the surgeon is placed will form some excuse for the occurrence, but also on other occasions when no such apology for the error can be found. Occasionally an incision is made as an exploratory measure, acknowledged doubt existing as to the presence or otherwise of the foreign body sought to be removed; but an experimental search of this kind, when made on sufficient grounds, has no correspondence with the mistakes above indicated. They are illustrations of an incision being made for the purpose of removing something, under the supposition that it is a projectile, when its true nature might have been determined by proper investigation beforehand; and they are only mentioned to call attention to the necessity for not operating without sufficient circumspection, even under the exciting circumstances in which surgeons are sometimes placed in military practice.

When a surgeon, after due examination, has obtained satisfactory evidence that the removal by incision is necessary, before using the knife he should fix the bullet or other foreign body in its place by pressure upon the soft tissues on either side of it. If it be lying rather deeply among muscles, or under any circumstances where it is not likely to slip away under pressure, this is best done by putting the adjacent superincumbent parts on the stretch with one hand preparatory to cutting down upon it with the other; but if it be very superficial just below the skin, or skin of fascia, the foreign body together with the integument can be grasped between the fingers of the surgeon, and held securely while the necessary cut is being made towards it for its removal. In some situations it is more convenient for an assistant to grasp the parts below the spot where the bullet is placed, and so to keep it steady, while the surgeon cuts down upon it. This simple precaution will often cause the extraction of a foreign body to be easily and rapidly effected, when, without it, delay would ensue from the projectile slipping away as soon as pressure is made upon it. In the instance

of a round bullet the incision should be carried beyond the length of its diameter, an addition of half a diameter being usually necessary to admit of its easy extraction; in an elongated bullet the length of the incision must depend upon the aspect of the projectile which is presented towards the surface. The opposite margins of the foreign body should be fully exposed. Where there is a risk of the ball being pressed away by the knife in the act of cutting down upon it, especially if it be stuck in the wall of a cavity, as of the chest (a situation where sometimes neither the surgeon nor an assistant can keep it fixed in its place by the means above mentioned), and still more so if there is reason for believing the wound communicates with the interior of the cavity, the incision should be made on one side of the bullet instead of over it; and, when the projectile is exposed, it is better to secure it from slipping away by grasping it with the mouse-toothed forceps, or, if this instrument be not at hand, no attempt should be made to lay hold of it, until a scoop or steel director has been carefully insinuated behind the projectile. When once the director is safely behind it, and so maintained, the bullet may be tilted forwards, or grasped by an ordinary forceps and removed without risk of pushing it into the cavity.

In some parts of the body, after an incision has been made down to a bullet which is lodged deeply, its extraction may be facilitated by placing the parts concerned in certain positions, just as it may be rendered difficult by putting them in others. Some attitudes will bring a bullet nearer to the surface than others. Some will cause structures to be tightly stretched across a foreign body; in others, these same structures will be relaxed or moved aside. The removal of a bullet lodged in the popliteal space, will necessarily be found to be a much easier operation in the extended position of the limb, than when the knee is flexed. These circumstances should be considered in all cases of deep lodgement, according to the anatomical parts involved. An ingenious application of this precept is afforded in a case related by M. Briot, in which he removed a bullet that was fixed between two ribs under the right shoulder-blade. The ball had originally traversed the scapula, and was felt to be nailed solidly between the two ribs. After a free incision, the bullet-opening in the scapula was enlarged. M. Briot then passed behind the bullet the end of a scoop, and, pressing upon it, he ordered the patient to take in a very full breath in order to separate the ribs as much as possible. This movement enabled him to disengage the projectile and effect its extraction.[12]

If efforts have been made for some time without success to effect the extraction of a foreign body, and the continuance of them be considered to be detrimental to the patient, or if from any other cause it be determined not to make further attempts at its extraction in the early period of the case, it is best to leave the lodged

body alone until the first inflammatory period has passed. The removal of foreign bodies deeply lodged is sometimes rendered more easy when suppuration is fully established. The displaced particles of areolar tissue which often surround the foreign body become disintegrated still further and soften down, the foreign body becomes surrounded by glutinous pus, and, under these circumstances, if the position be favourable, and especially if the foreign body be a heavy one like a bullet with a smooth exterior, it will sometimes change its situation and approach nearer to the surface; or it may reveal the exact site of its lodgement by marked local inflammatory signs, by pain, or other indications, and its removal may then be effected in the manner previously described without difficulty. If these occurrences do not take place, and the presence of the foreign body simply prevents the complete closure of the wound, leading to the establishment of a sinus, or if irritation is not kept up by it, but the foreign body becomes quietly encysted, then the question becomes one which belongs altogether to a later period of treatment.

There are certain positions in which the lodgement of a bullet, or other similar foreign body, entails consequences so dangerous to life, that although their extraction cannot be attempted by any other means than by operative measures which themselves involve very great risk to life, yet these operative measures are held by some surgeons to be proper for adoption. Of the two dangers the danger of the operation is held to be less than that of the continued lodgement. These are debatable questions in surgical practice. They remain in doubt from one of two reasons, or it may be from both combined, viz., because sufficient experience has not been yet gained for their settlement, or because successive improvements in operative surgery are causing the hazards attending particular operative proceedings to become lessened. The case of a bullet lodged in one of the pleural cavities, or of one in the cavity of the peritoneum, affords examples of the debatable points I now refer to. Most surgeons object to lodged bullets in these cavities being searched for, but M. Baudens in France, and more recently M. Legouest, Professor of Military Surgery at the Val de Grâce, on the contrary, have advised that in any such case, the external wound should be enlarged by incision, and the projectile searched for with a view to its extraction.[13] An approval of this advice has been given in a report by Dr. Otis, issued from the office of the Surgeon General of the U.S. Army.[14] I only refer incidentally to this subject, for the questions connected with it include so many local and special considerations, that they can only be properly discussed when the wounds of the particular regions concerned are under study.

Occasional cases will occur in which it appears desirable to place a patient under the influence of an anæsthetic while performing the operation of examining the nature of his wound and searching

for foreign bodies in it. There is little doubt that under these circumstances, as in all other cases in which surgical operations have to be performed in the field, of all anæsthetics chloroform is the most suitable for the purpose. The use of æther is advocated in preference to chloroform by some surgeons. Æther may well be used in fixed hospitals, but, in the field, its administration generally occupies more time than can be spared without detriment to other patients; and, in fact, it is hardly practicable to carry it for field use on account of the quantity which would have to be expended, and the consequent space that would be required for its conveyance. Surgeons in the field should always economise the consumption of chloroform as much as they can. If it be expended wastefully, the supply, however ample it may appear at first, will certainly be exhausted in case of any large demand before the vacant stores can be renewed, and much avoidable suffering will be the consequence. Dr. Chisolm of South Carolina, where chloroform was a very rare article during the Civil War, invented a form of chloroform inhaler, the object of which was to ensure that none of the precious drug might be wasted even when administered in the open air. It consisted of a closed metal receptacle for a sponge on which the chloroform was poured. At one end of this case there was a fine wire grating for the passage of air, while at the other end were two short tubes, suitable for being inserted into the patient's nostrils. The vapour of the chloroform was inhaled through the nose, while such free air as was necessary was admitted by the mouth. One of Dr. Chisolm's inhalers, which he was kind enough to send me, may be seen in the Museum of Military Surgery at Netley. When chloroform is not so scarce, either the ordinary cone of lint, or linen, held in the hand and applied over the patient's nostrils and mouth, or one of the German inhalers in which a piece of flannel is stretched on a wire frame, forms the most ready means of administering the anæsthetic; and, with ordinary care and observation, is probably as safe as any of the specially constructed and more complicated instruments for the purpose, which are too often liable to become disarranged while in use.

As soon as the projectiles, or any other foreign bodies that may have been detected, are removed, the wounds are to be cleaned and dressed. Penetrating wounds caused by small projectiles are seldom accompanied with much laceration or disturbance of the parts near the openings of entrance; but it will frequently happen, even in simple flesh wounds, when a bullet has passed entirely through the limb or part of the body which has been wounded, that the soft tissues near the wound of the exit are much torn and displaced. Superficial rasing wounds by small projectiles, and wounds over some of the superficial bones, are often accompanied with a good deal of laceration. In such cases, on dressing the wound, attention

must be first given to clearing away all clots and foreign matters there may be upon it, and then to readjusting and securing the disjoined structures as closely as possible in their normal relations to each other. In thus bringing the parts together, the purpose is not so much to try and obtain primary union, which under ordinary circumstances can only be expected to take place very partially between the lacerated and divided surfaces, as it is to give ease to the patient, and to prevent avoidable irritation and malposition of parts during the subsequent stages of cure by granulation and cicatrisation. This readjustment carefully done, will give the structures an early tendency to adapt themselves to one another in the same relations in which the surgeon hopes they may be ultimately united. The best method of clearing away clots, and such extraneous substances as dust, fibres of cloth, earth, and grit, from the torn surfaces of wounds, is by squeezing water from a sponge, or by pouring it from an irrigator or any other convenient vessel upon them. Such things as small gravel and dust are more often pressed into the exposed tissues than removed from them by the use of tow, sponges, and similar articles, when directly applied to their tender surfaces.

The additional bruising and irritation which may be caused in this way, and the increased impediments to a favourable healing process, are so obvious as not to require mention. The surface of the skin adjoining the wound should be cleared in the ordinary way, by at once carefully sponging away from it all blood, and measures should be adopted to prevent as far as possible its spreading again on the occurrence of oozing. This can be readily done when the wound is first dressed, but can only be accomplished with considerable inconvenience after the clots have become hard and firmly adherent to the skin; especially after inflammatory action has begun and all the parts involved in the injury have become heated, dry, and highly sensitive.

The dressings to be applied, and the further treatment of wounds produced by small projectiles, will be described in the next chapter.

CHAPTER III.

LOCAL TREATMENT OF GUNSHOT INJURIES FROM SMALL PROJECTILES.

Moistened lint as a dressing.—In simple perforating flesh wounds, and in gaping and lacerated wounds, by small projectiles, after the torn and divided structures have been brought into proper apposition, the dressing which has been most generally employed by British surgeons in field practice has been lint moistened with plain water at the ordinary temperature. Water

has many advantages as a dressing. It is grateful to the sensations of the patient, it is easily medicated if required, is easily renewed, and can generally be got in any required quantity. Well made lint, too, has the advantage of being of all substances the softest and most agreeable to sore and inflamed surfaces; it imbibes a large quantity of any fluid in which it is properly steeped; the saturation is easily maintained; and, in this moistened condition, it yields and readily adapts itself to the shape of any parts of the body to which it may be applied. All kinds of dressing that involve stiffness, pressure, weight, and undue warmth, are objectionable.

Poultices of linseed meal, though sometimes used, have most of the objections last named in a marked degree. Moreover, to make them well, more time is required than can usually be given in field-hospitals; the materials for their manufacture are not easily transportable, owing to their bulk; they cannot be renewed in field-hospitals as frequently as they may be in fixed hospitals in towns; and as they retain the discharges, whether purulent or decomposing, chiefly on their surface, they soon become offensive and act as irritants in the neighbourhood of the wounds. After a time, too, probably by preventing evaporation owing to their oily constituents, they sodden the parts over which they are placed, lessen their tone, and in this way appear to impede a vigorously healthy action. There is besides some difficulty in getting rid of them after they have been removed, and it requires the close attention of surgeons to prevent them from being thrown away as refuse in some obscure place in the neighbourhood of the hospital where they are not likely to be seen, but where, if they are allowed to remain, they soon begin to assist in attracting flies as well as rendering the surrounding atmosphere impure. Linseed-meal poultices ought to be excluded entirely from use in field-hospitals. The ordinary water-dressing is far better, for it is free from the objections which have just been enumerated.

In using water-dressing in field-hospitals, the lint is kept moist either by removing and wetting it from time to time as it becomes dry, or by dropping water occasionally upon it from a sponge, a vessel of water being kept at the bedside for the purpose; or, what generally answers better, from a fixed irrigator adapted to the position and other circumstances of the wound. Sometimes the water-dressing is employed covered, the lint being kept moist by preventing evaporation; oiled silk, gutta-percha tissue, waxed paper or linen, or a second layer of lint on which some ointment has been spread, being used for the purpose. On consulting a patient's sensations in the selection of either of these modes of dressing, climate and temperature will generally be found to determine his choice. In hot climates cool evaporating applications are the more grateful, and, by lessening the degree of reaction, checking the

amount of inflammation, as well as circumscribing its extent, are usually the more advantageous; in cold climates, the non-evaporating applications are the more agreeable. This was the local system of dressing gunshot wounds adopted by English surgeons in the Crimean, Indian, New Zealand, and other wars, and under it they generally healed very favourably.

During the last few years this simple treatment has been modified. The water, if employed as a dressing, has been medicated by some antiseptic or other ingredient, especially after suppuration has commenced. Other applications have also been employed, some of which will be presently mentioned.

Charpie.—Charpie, or linen separated into short threads about two or three inches long, is the material which has hitherto been in common use all over the Continent, instead of lint as manufactured in England. It is scarcely at all used by British surgeons. I do not think that the absence of it from the regulated dressings of English hospitals is any loss. In consequence of the general use of linen by persons in most of the continental countries of Europe, —even for shirts among the poorer classes,—all articles of linen, when no longer fit for their original purpose from age, are apt to be converted into charpie. New linen is considered unfit for charpie on account of the fibres being too rigid and hard; while half-used linen, being soft and flexible, is found suitable for the purposes to which charpie is applied. In Continental hospitals, the half worn out bed linen and old articles of personal clothing, are generally converted into charpie. However clean the linen may appear to be before it is pulled into the separate threads for charpie, it is difficult to believe it can be quite free from some remains of the emanations, liquid and gaseous, with which it must frequently have been saturated while in hospital use. Sanious and purulent discharges from sores, and the other decomposable substances with which such articles of linen are habitually soiled, and some of the effects of which it must be so difficult to eradicate, however well it may be washed, naturally occur to the recollection in thinking of the origin of charpie thus prepared for surgical purposes. And after it has been collected and stored for use, charpie is so absorbent from its light, fibrous, and porous character, that it must, like charcoal, readily absorb any gaseous emanations among which it may happen to be placed; while, unlike charcoal, it contains no quality which may help to neutralise or correct their deleterious effects. Remarks of a corresponding nature will apply in regard to the employment, frequently adopted in foreign hospitals, of charpie for cleansing parts in the neighbourhood of sores, instead of tow or sponges. The surgeon's tow manufactured in England for hospital purposes, or well-carded oakum, answers this last purpose equally well with charpie: while neither of them are so liable to be contaminated by the deleterious influences which

undoubtedly have led in some instances to ill results from the use of charpie abroad.

Charpie has one advantage over lint, viz., its superior capacity for absorbing a thick viscous fluid, such as pus, when it is poured out copiously from a wound. When the discharge of pus is as moderate as it ordinarily is in healing wounds, the inferior absorbent powers of lint do not attract notice. There is no obstruction to the escape of the pus, for it is removed as it collects on the lint by the periodical dressings. When, however, purulent matter is discharged in large quantity and it accumulates rapidly on the surface of the lint, charpie, if its purity can be relied upon, may be advantageously employed in conjunction with the lint, not instead of it, as a dressing. In such a case, the lint being laid on the sore surface, an arrangement is made for the excess of pus to flow out at one of its edges, where the charpie is placed to absorb it as it drains away; or the perforated, or lattice, lint is employed, and the charpie being laid over it and lightly retained in its place, is enabled to soak up the pus as it passes out through the open spaces of the lint. Similar means may be employed in deep hollow wounds when the discharge is profuse in quantity.

Charpie containing a certain proportion of tar dissolved in carbolic acid has been specially manufactured in this country, and may be more advantageously employed in the way named than simple charpie, owing to its deodorant and antiseptic qualities. Calvert's carbolised charpie has all the characteristic features of common charpie, and only differs from it in being brown in colour, and in having a tarry odour.

Carded oakum as a dressing for gunshot wounds.—During the War of the Rebellion in the United States, common picked oakum made from ships' ropes—an old application to wounds among sailors—was introduced as a cheap substitute for lint and charpie, and became extensively used in the field and general hospitals. Picked oakum has since been used in some civil hospitals in Europe, and was largely employed in the military hospitals in France during the late German invasion of that country. The particular advantages of it have consisted in the abundance with which it can be readily and cheaply obtained; in its capacity as an absorbent, owing to the curled and twisted condition of its fibres; in its antiseptic qualities, due to the tar with which it is more or less imbued; and lastly, in the facility with which, after having been used, it can be got rid of by combustion, owing to this last-named substance entering into its composition. Its chief demerit was the coarseness of its fibre, so that it acted as an irritant when used as a dressing for tender and sensitive sore surfaces; while, for wounded parts unavoidably subjected to continued pressure, or for bed sores, it could not be tolerated as a covering at all. To get rid of these inconveniences several finer sorts of oakum, carded by

machinery, have been introduced as articles of commerce.[15] The more delicate texture of this specially prepared oakum does not appear to interfere with its absorbent power. At the same time, being softer, smoother, and less resilient, it can be applied without inconvenience to the proximity of inflamed and tender orifices of wounds, or to the neighbourhood of granulating sores, and may thus be used for soaking up the purulent discharges proceeding from them. It is doubtful whether any form of oakum can ever be judiciously applied as a dressing directly to the delicate granulating surfaces themselves.

The ill effects of the hardness of the common kinds of picked or carded oakum can be obviated to some extent by interposing fenestrated linen, not lint, between the granulations and the oakum, without interfering with the escape of the pus and its absorption by the dressing; but as a certain amount of pressure by bandage, or otherwise, has to be exerted in order to keep the oakum in its place, its roughness will still occasionally make itself felt objectionably. It seems probable therefore that oakum under almost all circumstances will remain too coarse to serve the purpose of a substitute for ordinary lint, though it may be used like charpie in combination with fenestrated linen. For most of the hospital purposes to which 'surgeon's tow' has been usually applied—such as soaking up discharges from the neighbourhood of a wound, for making small pillows and pads by enclosing it in suitable linen bags, for padding splints for cases of fracture, after being overlaid by lint or soft linen,—common picked oakum will serve equally well, and perhaps much better, owing to its antiseptic qualities, when the hospital cases under treatment mainly consist of injuries produced by gunshot.

Antiseptic and deodorant applications.—Attention has been of late years so strongly and so widely directed to certain antiseptic and deodorant preparations in consequence of the large scale on which they have been manufactured at a cheap rate for sanitary purposes, but more especially on account of the great success which has attended their use in the practice of Professor Lister and others in the treatment of the wounds and injuries caused by accidents in civil life, that it can be no matter for astonishment that they should also have come to be very extensively employed in military practice in the treatment of gunshot injuries. During the late war between Germany and France, two of them, the permanganate of potash, and carbolic acid, especially the latter, were more extensively employed in both field and fixed hospitals than they had ever been previously; indeed, under different forms of preparation, or in different degrees of strength, one or other, if not both, may be said to have been universally employed in all the hospitals, both French and German, during the war.

The permanganate of potash, or Condy's solution, has been a

good deal used by English surgeons, and a very valuable adjunct to the dressings of gunshot wounds it has proved itself to be, from its quality of destroying the offensive odours which accompany their discharges. It is very valuable in a highly diluted form as an injection for seton-like wounds or suppurating wounds of much depth. But as a general antiseptic this drug hardly appears to be either so energetic or efficient as the carbolic acid, or as another which has been occasionally used, viz. the chloride of zinc. Moreover, the difficulty of getting rid of the stains which it leaves on linen and other articles, when the concentrated solution accidentally comes into contact with them, is another objection to it for use in general hospitals.

Carbolic acid, under the name of phenic acid, was employed to a considerable extent after the principal battles of the Italian campaign of 1859, and again during the Mexican campaign, in the French military hospitals. But, as just now mentioned, it was used on a still larger scale than ever in the hospitals of the German and French armies during the prolonged war of 1870–71. One of the great advantages attributed to the use of carbolic acid in the treatment of wounds is that it prevents the development and spread of their most dreaded complications—septicaemia, pyaemia, hospital gangrene, and erysipelas. How far the use of the carbolic acid has succeeded in accomplishing this end in the military hospitals where alone these fatal scourges are usually rife, viz. in the rapidly improvised and generally crowded hospitals near battlefields, can hardly yet be determined. The reports by different surgeons of the results of its employment in these hospitals have been very contradictory: some praising its efficiency, others declaring that septicaemia, pyaemia, and typhoid fevers prevailed as much in places where it was used as in others where it was not. In garrison hospitals, where the conditions by which such unhealthy complications of wounds are usually generated in an epidemic form do not, or ought not to, exist, the influence of these disinfectants has not been placed so much under trial with regard to the subject in question.

I have no doubt myself respecting the very great value of carbolic acid as an antiseptic dressing in the treatment of gunshot wounds when it is properly employed, that is, when it is so diluted as not to act as a caustic or irritant to the skin; and I hardly think a surgeon would now be justified in conducting a hospital containing many wounded patients without using it freely. But I do not anticipate that, under any mode of applying this agent, gunshot wounds can be got to heal by simple adhesion or without suppuration, as has been suggested, almost as if they were incised or simply lacerated wounds. The antiseptic qualities of carbolic acid are beyond doubt most valuable. Its local effects on the fetid discharges and sloughs thrown off from the wounded surfaces are

advantageous, by arresting their decomposition, and thus checking their tendency to excite putrefactive processes in the fluids and tissues with which they are in immediate contact. They are additionally so by preventing the dissemination of the noxious effluvia which, without some such neutralising influence, would inevitably load the atmosphere surrounding a collection of patients suffering from gunshot wounds in various stages, and complicated, in many instances, with severe fractures of bones.

Professor Lister, who has done so much to advance the use of carbolic acid in this country and on the Continent, whose mode of employing it is based, as is well known, on the germ theory of the propagation of disease, published, not long after the Franco-German war commenced, some directions entitled 'a method of antiseptic treatment applicable to wounded soldiers.' These instructions for the first dressing of wounds will be found in the appendix.[16] Unfortunately, to anyone practically acquainted with the state of things after battles, it will be at once obvious that the plan described must be on almost every occasion of such an event taking place incapable of execution. Even if the material means could be found on the spot for carrying out the directions, no army surgeon would have the continuous time for putting them into practice without neglecting other cases of extreme urgency, which, on such occasions, press for attention on all sides. Let anyone consider what the usual situations of wounded men are during the first twenty-four hours after a battle, or even after an engagement of minor importance, the circumstances which surround them, and the occupations of the relatively few non-combatants during that space of time; and it may easily be understood how rarely any very methodical plan of treatment which requires particular surgical care can be carried out in individual cases under such conditions. Let also the frequent removals of the wounded during the military operations, the methods of removal, and the limited opportunities of surgical attention in the course of them be further remembered, and the difficulties in the way of the application of the antiseptic treatment of wounds in its integrity will be still more apparent. Even if the germ theory of suppuration be admitted as an established fact, yet, from the nature of gunshot wounds, and from the circumstances under which they are inflicted in warfare, it is scarcely credible that any plan of treatment, the success of which must depend on the rigid exclusion of such germs, can ever possibly be carried into practice in the field.

Chloride of zinc has been chiefly employed as an antiseptic in the Royal Navy. A solution of it was first used by Sir William Burnett for preserving timber and canvas from the spread of dry-rot and other minute fungi, and afterwards as a general disinfectant. For many years it was the only one permitted to be used on board ships of war, where it was known under the name

of 'Burnett's Disinfecting Fluid.' It thus came to be applied as an antiseptic lotion to gunshot wounds. Inspector-General Sir Wm. Smart, R.N., has published the results of his experience regarding the use of chloride of zinc in these injuries,[17] and has written very favourably of it. He advocates its use in the primary treatment of all gunshot wounds, declaring it to be preferable to carbolic acid or any other antiseptic for hastening the separation of sloughs, and for checking unhealthy action tending to sloughing. The same distinguished naval surgeon has also praised the influence of chloride of zinc when applied to the surfaces of stumps after amputation exhibiting a tendency to hospital gangrene. The late Mr. de Morgan, of the Middlesex Hospital, whose practice it was to sponge the surfaces of wounds made by surgical operations with strong solutions of chloride of zinc, has also advocated the use of chloride of zinc in preference to other antiseptics in the treatment of gunshot wounds.[18] He recommended 'a solution of 30 to 40 grains of the chloride in an ounce of water, applied freely in the crevices and dark corners of the wound, sponging it in until the whole surface is creamy, then covering the wound with lint wetted with a solution of 5 grains to the ounce of water, keeping the covering constantly wetted with the lotion.' The use of salicylic acid in various forms has recently been strongly advocated as a dressing for gunshot wounds, from having less irritating qualities than carbolic acid, and at the time possessing all its advantages as an antiseptic application. Professor Esmarch has especially called attention to its merits,[19] and he has devised various means for making it applicable in the field. Instead of the lint and ordinary bandage in the 'field dressing' carried by each soldier, Dr. Esmarch substitutes salicylised cotton charpie and a piece of salicylised gauze bandage. All cotton wadding and tow for field use are also to be salicylised. Dr. Esmarch has also prepared small swabs of salicylised jute enclosed in salicylised gauze for wiping blood from wounds, with a view to their being carried in the dressing-cases of all hospital attendants, and by all bearers of wounded. By the use of these materials, and by abstaining from all exploration of wounds at dressing stations or elsewhere in the field, and only treating the wounds under antiseptic precautions after the patients have arrived in hospital, Dr. Esmarch believes the antiseptic plan of treatment may be carried out in its integrity: and he infers that some of the most severe injuries in war, such as gunshot wounds of bones and joints, may run through a thoroughly aseptic course, and be got to heal almost without suppuration and without fever.

How far the antiseptic treatment can be carried out on this plan, and with what results, cannot be fairly told until it has been subjected to the test of experience. Hitherto copious and long-continued suppuration has been one of the ordinary sequences to the majority of severe gunshot wounds inflicted by both rifle and

massive projectiles. The amount of suppuration has been reduced by the greater attention which is now being generally given to hygienic arrangements, and especially to cleanliness in the manipulation of wounds (a matter, however, which few English surgeons have neglected); but I fear the day is still far distant when suppuration will not be met with during the process of cure in a very large proportion of them.

Treatment during the suppurative process.—The treatment after suppurative action has been established will, therefore, next be considered. Although in this stage a surgeon must be guided by the general rules applicable to all suppurating wounds or sores, it will be evident, on reflection, that especial care is necessary to obviate the accumulation of pus in gunshot wounds, which are so frequently deep, narrow, and tortuous, and so often traverse many different structures. Indeed, the gathering of collections of matter at some distances from the openings of entrance of projectiles, and the fact of pus travelling widely between muscles and fasciæ, are well known to be not unfrequent occurrences with them. In many instances these purulent dispersions are to a great degree the results of want of sufficient caution on the part of the surgeon: too much confidence is placed upon nurses or other attendants who are unaware of the great importance of avoiding such purulent accumulations, or neglectful of the duty. The surgeon who has his patient's interest at heart will personally assure himself that the evacuation of discharges is regularly accomplished. If matter, notwithstanding the precautions taken, do not flow away freely, and this appears to be owing to some mechanical obstruction at or near the opening of the wound; or if the opening appear to be too small in proportion to the dimensions of the cavity of the abscess to ensure a continuous and sufficient discharge of the pus according as it is formed; or if a collection happen to have taken place and is detected at some point more or less remote from the track of the projectile—then no time should be lost, but the necessary incisions should be at once made for its evacuation. The retained pus is a fertile source of febrile excitement, while, at the same time, it has a constant tendency to diffuse itself, and thus to widen the area of irritation. An hour's delay in such a case may have a very deleterious influence on the progress and ultimate results of some wounds.

Drainage tubes.—Some surgeons rely greatly on the use of the perforated caoutchouc drainage tubes of M. Chassaignac for ensuring the steady escape of purulent discharges in gunshot wounds, especially those accompanied by long sinuous tracks, and those in which collections of pus lie at a considerable depth. I have not myself seen the advantages which some surgeons attribute to them.[20] It rarely happens that the pus may not be thoroughly evacuated without them, by proper counter-openings, and by regularity and care in the dressings; when the irritation of a foreign

body in the wound, however moderate it may be in the particular case under notice, will be avoided. The ordinary drainage tubing is often troublesome and inconvenient in practice both to the surgeon and patient. Sometimes the perforations in the drainage tube, sometimes the main canal, become plugged by thick particles floating in the pus, when the instrument of course ceases to act in the way intended. Sometimes the tubing becomes flattened by accidental pressure, when the same result ensues. Such drainage tubing as is usually met with in England is very inferior in quality; it easily becomes decomposed, loses its elasticity, and breaks asunder. Drainage tubing if employed in wounds should be free from all irritating qualities as regards its material: it should have a soft surface; be of sufficient calibre not to be easily blocked up, yet not so large in diameter as to press unduly against the sides of the track of the wound; and sufficiently resisting for the tube to remain open notwithstanding the amount of pressure to which it is liable to be subjected by the tissues along which it is placed. When employed, it should be removed at least twice daily, and should be washed in a little weak carbolic acid or permanganate of potash solution. The tube should be examined each time to see that no part has become brittle. The drainage tubing manufactured in France is much more effective and safer than that which is manufactured in England. It has been stated that the spiral wire drainage tubes designed by Mr. Robert Ellis are still better for the purpose. Similar tubing can be easily made by coiling either brass or copper wire of the proper size round a metal catheter. These tubes are best introduced on a long silver probe which can be bent so as to convey them in the proper direction, but they can be inserted without this help by a little management.[21]

Use of sawdust bags as applications to suppurating wounds.—My friend Surgeon-Major Porter has been applying a very cheap material, viz. fine sawdust, in a very useful way, for some time past, in the treatment of suppurating wounds. The sawdust is placed loosely in small bags of thin gauze, and these are put to the seats of suppuration. The meshes of the gauze are not large enough to let the sawdust pass through them, but freely admit the fluid discharges. The patients find the application of these absorbent bags easy and comfortable in all respects. They preserve an even temperature, and there is no harshness about them. But the most important advantages from their use are, firstly, that the pus does not spread over the surface around the wound,—it goes directly into the sawdust, and hence the tendency to erythema or excoriation is obviated; and, secondly, that the sawdust acts as an antiseptic. The only odour that can be perceived when the dressing is changed is that of the turpentine with which the sawdust is impregnated. The sawdust used at Netley has been obtained from steam saw mills, and the particles are very soft to the touch.

The pine-wood selected is the Memel pine, as that appears to be the richest in turpentine, judging from the odour.

Treatment of gunshot wounds by irrigation.—At the time of the Danish War of 1864, the attention of surgeons in military practice was particularly called to the treatment of gunshot wounds by irrigation by Professor Esmarch, of Kiel, and it subsequently became a regular part of their treatment in all German military hospitals. It must be admitted that the practice of irrigation under certain conditions is of much value; at the same time, in the hands of some surgeons its use seems to have been carried to an unscientific and deleterious extent. The appliance known as 'Esmarch's irrigator' consists of a cylindrical metal vessel holding about a quart or more of water. Near the bottom of it a tap is fitted, and, connected with this tap, is an indiarubber tube about two feet and a half long, terminating in a nozzle with a fine bore. This apparatus is employed either for the continued irrigation of wounds, or for occasionally syringing them. When used for continued irrigation, the vessel itself is placed at a suitable elevation on a shelf, and the tube being properly supported, the water is made to flow upon the wounded part either in a slight stream, or drop by drop at the discretion of the surgeon. A trough is provided for carrying off the water into a receptacle by the side of the patient's bed. When used for syringing, the water-can is either held aloft by an attendant, or placed upon some elevated support, while the surgeon directs the stream issuing from the nozzle wherever he may deem necessary. If it be placed in the opening of a canal-like bullet wound, there will be a continuous flow through it and out at the wound of exit; or, if directed upon an open granulating sore, its surface may be thoroughly cleansed over all its parts successively. The higher the vessel is placed, the greater will be the force with which the stream will issue. In most military hospitals metal dishes, made with edges of such different curves that they can be closely applied to any part of a patient's body or limbs, are conveniently employed for catching the water and discharges as they escape from the irrigated surfaces of wounds. Separate nozzles should be issued to each patient, so that there may be no risk of spreading contamination from one patient's wound to another.

Different opinions have been expressed regarding the merits of the plan of treating wounds by continued irrigation, probably owing to the very different kinds of cases in which it has been employed. My own observation leads me to believe that in many instances, especially in those of men who have become constitutionally depressed from any cause, the healing process is retarded by it. It is quite true that continued irrigation is a powerful means of restraining inflammatory action; but, in doing this, it also materially interferes with that afflux and action of the blood in the vessels adjoining the wound which constitute a necessary

part of the process of repair. Under its influence the granulations at last lose the florid vigorous hue which indicates healthy action, and assume a pale and œdematous aspect, while the pus at the same time ceases to have that thick creamy appearance which is so characteristic of it in its most healthy state. How much these effects are due to the irrigation being kept up with undue force, so that a deleterious amount of disturbance is caused by it among the delicate granulation cells, and the changes which are necessary for their conversion into new tissues prevented; how much to the continued stream soddening the granulating surface and the surrounding skin, and so depriving them of that contractile power which constitutes part of the healing process; how much to too great lowering of temperature by the incessant abstraction of heat as the water flows over and away from the wound; it is difficult to define. It is probable that all these causes combine to interrupt the healing process when the irrigation is long continued. As a remedy when inflammatory action runs high and there is great heat in the wounded part, especially in wounds of joints, continued irrigation may be turned to a very useful account; but when indiscriminately applied to the cases of such patients as are usually found in military hospitals, it will probably be productive of much more harm than good. Indeed, experience seems to have shown this to be the result of its general employment, for the plan of continued irrigation has of late, I am informed, lost favour in almost all the hospitals where it was formerly employed.

The use of the irrigator seems now to be in a great measure restricted to its employment as an instrument for occasionally washing suppurating surfaces, and especially for syringing those wounds which present more or less of a fistulous character. For this purpose it is most useful. In the last-named class of wounds, as the water passes through the bullet track, it dissolves and carries away the pus, and so averts the danger of accumulation. Should fibres of cloth, hairs, or any similar light foreign substances, be caught in the sides of the canal, the flow of water thus directed will often serve the purpose of dislodging them. For these objects the irrigator offers particular advantages. But in using it care should be taken that the stream of water be not impelled with undue force, or poured too persistently. It must be remembered that a certain amount of pus is the natural covering and protection of granulating surfaces, and while nothing should be more deprecated than an undue accumulation of purulent discharges in the vicinity of wounds, the forcible and complete denudation of the tender granulations of the healing surface, so long as the pus presents a healthy character, is an unscientific, and can be, under no circumstances, a wise interference with the natural process of cure. While providing for the most free and easy escape of all superabundant discharge, it is the surgeon's duty, particularly when a wound is

granulating healthily, carefully to abstain from all such rough and forcible applications to the sore surface as will either bruise the granulations themselves, or entirely deprive them of their natural covering. When the irrigator is used for cleansing wounds on the plan just referred to, it is advisable for the water to be moderately warm. If any sloughs are being thrown off, or if the suppuration be copious, the addition of a little Condy's fluid, or a minute proportion of carbolic acid to the water, is advantageous. The Condy's fluid is, I think, less irritating than carbolic acid under these circumstances, however much it may be diluted. As soon as the irrigation is completed, and the parts adjoining the wound dried, the fresh dressings, whatever their nature, should be at once applied to the wound, and the other arrangements for the patient's comfort and protection completed. If the wound be one from which there is a profuse discharge, the irrigation and dressing should be performed morning and evening; if moderate, they should be done every morning. No means should be neglected to prevent purulent accumulation, and to ensure complete cleanliness in the vicinity of the wound.

Wounds in an atonic condition.—After the suppurative flow has continued for some time, if the healing action in a wound should appear to be checked from any cause, if the part of it exposed to view assumes an asthenic appearance, the granulations being pale and œdematous, the discharge thinner, and all the general indications being those of want of restorative power, weak astringent solutions may often be advantageously employed for syringing it, instead of the antiseptic water. The object here is to excite a more vigorous action in the surfaces of the wound. The good results of the perchloride of iron employed locally in this way have been greatly extolled on the Continent. But, to be thoroughly effective, the local applications must be assisted by the administration of appropriate constitutional remedies, and especially by a sufficiently supporting diet.

Great cleanliness necessary in treating gunshot wounds.—Under all circumstances, the strictest attention to cleanliness in its most extended sense—in all that concerns the manipulation of wounds, in the regular and complete removal of all foul dressings, soiled bedding, and other sources of infection, and in the free aeration of the wards with as pure an atmosphere as can be maintained—is essentially necessary, both for the comfort and general well-being of patients with gunshot wounds, as well as to allow the granulating process of repair in their wounds to go on healthily and without interruption. It cannot be expected, without these hygienic requisites, that the serious evils which result from the accumulation and dissemination of noxious effluvia, in places where many patients with sloughing and suppurating wounds are gathered together, would be averted, even locally from the wounds themselves, by any

amount of disinfectants or antiseptic agents. This subject will be again considered when the constitutional treatment of wounded patients is discussed.

Extreme cleanliness is also essential for protecting the patients against that troublesome source of irritation in camp hospitals, which has been elsewhere noticed, viz., the plague of flies. Protection of the wounds to keep off the approach of these insects, and cleanliness of everything applied to the sores, especially of sponges, in which the eggs of flies seem not unlikely sometimes to be deposited, are essential for preventing the repulsive complication of the presence of maggots in gunshot wounds. It is also important from another point of view, that careful attention should be paid to the means of obviating the access of flies to wounds. The extent to which these small insects act as carriers, and communicators, of infection is not known. Analogy and observation have caused their influence in this regard to be frequently suspected, though not to be sufficiently proved. All the more, therefore, when discharges more or less putrid are escaping from wounds, and sloughs are being thrown off, especially if at the time there are cases of hospital gangrene, erysipelas, or purulent infection, near at hand, should the most complete precautions be taken to ward off flies from wounds.

Topical applications to gunshot wounds used in some Continental hospitals.—Before quitting this part of the subject it may be well to mention the topical remedies which appear to be most in vogue among Continental practitioners in the treatment of gunshot wounds. Surgeon-General C. A. Gordon, who was in Paris during the siege of 1870–71, has enumerated the following as the remedies which were applied to wounds by the French surgeons, and by the surgeons occupied in the various foreign ambulances in Paris.[22] The applications are divided into three classes: simple, special, and styptic applications. The *simple* included charpie, dry or soaked in water, cold or tepid; compresses similarly moistened, glycerine upon fenestrated linen, poultices, oakum, agaric or amadou, and others. The *special* applications comprised aromatic wine; tincture of arnica, mixed with water or glycerine in various proportions; solution of permanganate of potash; carbolic acid, in the proportion of one part to ten parts of glycerine, or, as a lotion, one part to twenty of water, or with alcohol, the crystallised acid and alcohol being in equal parts, as an application to gangrenous surfaces; alcohol, of full strength or diluted with water; Lister's cerate, viz., one part of the crystallised carbolic acid, six parts of linseed oil, and nine of chalk, spread upon tinfoil; diluted spirits of camphor; nitric acid lotion, sixty drops to a pint of water, used extensively in the American Ambulance; irrigation by water alone or by diluted alcohol, sometimes continued uninterruptedly for several days; *poudre noir*, a preparation consist-

ing of permanganate of potash, chalk, and powdered charcoal, in equal parts, sometimes applied direct to the wound on charpie, sometimes placed over fenestrated linen soaked in glycerine. The *styptic* applications included the *papier hæmostatique*, and the tincture of the perchloride of iron, diluted with water in various proportions for general purposes, or undiluted, as a preventive of hæmorrhage after amputations and resections. Simple water dressing, Dr. Gordon mentions, was used only to an inconsiderable extent by the French surgeons. The late Surgeon-Major Wyatt, who was associated with Surgeon-General Gordon during the siege, mentions that neither ice applications nor leeches were much used. Ice was specially objected to by many surgeons on account of its influence in augmenting the intensity of subsequent reaction. He refers to the general use of arnica applications, and mentions that in France generally he found a prevailing belief in their beneficial effects.

Treatment of gunshot wounds by hermetically sealing their orifices.—A 'method of rapidly healing gunshot wounds' was brought to notice during the United States' Civil War by Dr. Chisolm,[23] of the Confederate States' Army. It was somewhat on the same principle that Dr. Howard of the Federal Army advocated the treatment of penetrating gunshot wounds of the chest by hermetically sealing up the aperture, or apertures, made by the projectile in its walls, and so excluding the access of atmospheric air to the wound. In a similar way Dr. Chisolm shut up the track of a bullet through the muscular coverings of the trunk of the body, or one through a limb, even though a bone, or bones, might be shattered. He called it 'converting gunshot wounds into subcutaneous injuries.' His description of the process was the following: 'Immediately after the injury has been received, when all foreign bodies have been removed, including fragments of bone, and when hæmorrhage has been checked, but long before any reaction has been established, make two elliptical incisions, extending only through the thickness of the skin, and enclosing the wound with its immediate surroundings of crushed tissues. Dissect up this elliptical flap of skin from the muscles, and two clean incisions are substituted for the ragged wound. If these incisions are carefully brought together by sutures, and the limb or trunk be supported by a roll of bandage, they will rapidly unite by the first intention; converting the track, however long it may be, into a subcutaneous wound which will heal rapidly without suppuration, by a process known as the remodelling process, which is well exemplified in the subcutaneous division of tendons.'

Dr. Chisolm anticipated the most important results from this mode of practice, not only in the rapid healing of the wounds but also in the escape of patients from hospital gangrene, secondary hæmorrhage, protracted suppuration, and other such complications.

The objection that the skin was not likely to unite over an excavated track was answered by the healing of an incision which had been made for cutting out a lodged bullet. A second objection, that the track of the wound is lined with crushed tissues which will slough, was thus answered—if the air be excluded, these tissues will disappear by absorption, just as suppuration and sloughing do not ensue, but the crushed tissues disappear, when small tumours are torn up subcutaneously. The surgeons in the field with the armies of the Confederate States were requested to test the efficacy of this practice, but the results, if trials of it were made, have not been published so far as I am aware. A copy of Dr. Chisolm's remarks was forwarded by the Director General to the principal medical officer in New Zealand during the last war in that country, so as to give the surgeons engaged in active operations in the field an opportunity to test the practice, if they found no objection to making the trial. It was tried by Staff-Surgeon, now Sir A. D. Home, V.C., and the result, so far as that officer's experience went, was decidedly unfavourable to it. The report of his observations is published in the Army Medical Reports for the year 1867, and will be found at page 523 of the volume. I cannot believe that the process will ever be found to be successful, or even generally practicable in field surgery, although it may be found to succeed in occasional cases of small wounds, such as pistol-shot wounds, under other circumstances.

Treatment by pneumatic occlusion.— Another method of attaining one of the principal objects of the hermetically sealing process, viz., the separation of the wounded surfaces from contact with the external air during the healing of wounds, is the plan of treatment by pneumatic occlusion, introduced by Dr. Jules Guérin.[21] This method has been the subject of much discussion in France. The proceeding consists in applying, over the part where the wound is situated, an indiarubber bag the edges of which are so adapted to the surfaces above and below the wound that no air can enter the bag. The bag is connected by an impervious tube with a glass globe, which is converted into an exhausted receiver by connection with an air-pump. The discharges from the wound flow along the tube into the glass globe without contact with air. The apparatus is so contrived that the discharges may be removed from the glass receiver without the admission of air, and, by reversing the action of the pump, lotions may be applied to the dressings over the wounds without removing the indiarubber envelope. Wounds have been treated by this method in France, but we have no experience of it, so far as I am aware, in England. Even if the treatment by pneumatic occlusion should repay its employment in fixed hospitals by any special advantages, the apparatus necessary for carrying it out is manifestly too elaborate for use in field-hospitals. Dr. Gordon reports that it was carried out by Dr. Guérin during the siege of

Paris, but it is evident that, even under the ordinary conditions of besieged places, the use of so complicated a system could not be usually resorted to. The simplest applications, and those that require the least time, are all that surgeons can practically use under the peculiar circumstances of military duty in time of war; and, if only the difficulties of meeting hygienic necessities can be overcome, such applications will generally prove most conducive to the comfort and best interests of the patients.

Treatment by cotton wool coverings.—Surgeon C. J. F. S. Macdowell, of the 3rd Bombay Light Cavalry, who served as a medical volunteer with some of the French troops during the siege of Paris, has published a pamphlet[25] in strong praise of 'a new method of treating wounds by Dr. Gruby,' from which he witnessed some remarkable results. Dr. Gruby practised at the Italian Ambulance in Paris. He altogether objected to the use of charpie as being a nest for animal and vegetable germs, and sought to get rid of microscopic, and even invisible, germs by the use of oil and cotton-wool dressing. Oil, he stated, is destructive of germs, while the cotton wool acts as a filter of the atmosphere. Cotton, unlike charpie, is a non-fermented and non-manipulated vegetable fibre. The oil forms an emulsion with the albumen of the wound; the formation being assisted by the capillary movement of the wounded part and the constant pulsation of neighbouring arteries, as well as by the vermicular and involuntary motion of muscles.

Dr. Gruby's practice was to place pellets saturated with oil on the wounded surfaces, to place a pad of cotton over the pellets, and then a bandage over all. Dr. Macdowell says that in all the wounds he saw dressed by this method an emulsion was formed, as above described; that the secretion of pus was very small in quantity; and that even on holding a 24-hours' dressing close to the nostrils, there was no offensive odour whatever. The patients told him they had never suffered any pain from first to last. Dr. Macdowell remarks that not a single instance of pyæmia or gangrene occurred among Dr. Gruby's cases; and he suggests that this would be a good treatment to adopt for wounds in India, where cotton is so abundant and cheap, and where grain oils, such as sesame oil, and others, are so inexpensive.

I have searched in various other reports on the surgery of the siege of Paris for observations on Dr. Gruby's system, and especially on its influence in warding off pyæmia and hospital gangrene as described by Dr. Macdowell, but have not succeeded in meeting with any remarks on the subject. I have not, however, seen any report from the Italian Ambulance itself. Other surgeons, especially M. Alphonse Guérin, have advocated the use of cotton wool, or cotton wadding, as an application for filtering the air and preventing the access either of germs, or of decomposing and irritating particles that might be in it, to the raw surfaces of wounds.

How far these views are confirmed by the test of practice admits of much doubt. There can be no doubt, however, that fine cotton wool forms a very valuable addition, when laid in sufficient quantity over the dressing of a wound, in any instance in which it is important to maintain an equable temperature. Its quality as a bad conductor of heat may then be turned to useful account, while its softness and lightness allow it to be applied to the most tender and sensitive parts with less inconvenience than any other substance. It is very unsuited for direct application to suppurating wounds in the condition it is generally met with, owing to its defective absorbent power. But this objection has been overcome in some specially prepared wool without apparently interfering with any of its useful qualities. There is a sample of cotton wool in the Museum at Netley (Spec. No. 723), which presents no difference in appearance from the ordinary cotton wool used for surgical purposes, but which has been so prepared as to have become highly absorbent. It does not contain any ingredient that can be detected by taste. A piece of it pulled out so as to present a substance very light in weight, on being thrust into water, so quickly absorbs it that it at once sinks to the bottom of the vessel. It was obtained from Leipsic. Cotton wool prepared for photographers has the same quality, though in a less marked degree. The fibres of the wool have had the resinous substance which coats them in their natural condition, and to which their non-absorbent quality is chiefly due, removed by caustic alkali. The alkali is then removed by ordinary washing. This prepared cotton wool is absorbent enough for all ordinary purposes as a dressing for wounds.

Prevention of muscular contractions and stiffness of joints during the healing of wounds.—I have elsewhere mentioned that no inconsiderable proportion of the soldiers, who have to be discharged from service in the army on account of the remote effects of gunshot wounds, are disabled by contractions. This circumstance leads me to call particular attention to the necessity for care being given to occasional alterations of position during the stage of suppuration, and, subsequently, to properly regulated passive motion, as part of the treatment during the period of recovery from such injuries. Sufficient notice hardly appears to have been hitherto directed to these points. Surgeon-Major Matthew, who was in charge of the Surgical Division of the Invalid Hospital at Chatham for a considerable part of the time when the men who had been disabled by wounds received in the Crimea were in progress of being discharged from the service, wrote in a professional report at that period: 'The contractions following wounds, from the great amount of suffering entailed upon the patients, the length of time usually necessary for their successful treatment, and the number of men lost to the service from this kind of disability, to say nothing of the tax on the time, ingenuity, patience, and resources of the

surgeon in carrying out such treatment even to a moderately successful issue, seem in my opinion to justify me in attaching a very high importance to the preventive treatment of injuries likely to be followed by contractions. It may be safely asserted, were due precautions as to position in the more acute stages of inflammation, early passive motion of the affected parts, and judicious exercise, enforced by the surgeon, that a very large proportion of cases of contraction, both after accidental injuries and gunshot wounds, which are now sent here, would never need admission into this hospital. There can be no question but that it is often very difficult and sometimes impossible to carry out such a line of treatment, as the co-operation of the patient cannot always be obtained; but, in my own practice in the treatment of gunshot and other injuries, I have usually found little difficulty in preventing a limb becoming fixed in a set position (even where the patient himself wished it to become so), by applying a splint one day and leaving it off the next, and by insisting on, and seeing applied, the use of passive motion.'

During the period when a copious discharge of pus is taking place from a wound there will not unfrequently be apparent difficulty in effecting the changes in position described by Dr. Matthew; for some one particular position, according to the nature of the wound, usually offers special advantages for favouring the escape of the discharge. But by due consideration of the purpose in view, and by the exercise of a little ingenuity in the arrangement of pillows and other supports, the difficulty can generally be overcome, and the required shifting of the limb or other parts that may be involved in the wound effected, without interfering with the free exit of the discharges, or with the ease of the patient. If a case of resection, in which a mobile new articulation is sought for, were treated in the same still and quiet way as a suppurating gunshot wound often is, very little final success would attend the operation. After dressing the wound, the supports and pillows are usually arranged, and the limb replaced in position, exactly as they were before the dressing was commenced: and this is carried on, day after day, until the patient is able to leave his bed. The patient, accustomed to one position, fears to have it altered: and at last, as the healing process goes on, as adhesions in parts adjoining the seat of injury become formed, and as all the structures gradually adapt themselves to the special relations established between them in the maintained posture of the part of the body concerned, any change will necessarily entail more and more pain and inconvenience in proportion to the duration of the time during which the state has continued. It is, therefore, as important to commence changes of posture early in the treatment, as it is to continue them throughout its course. When the healing process is complete, and continuity has been restored, even under the most favourable plans of treat-

ment, there will always remain a certain amount of stiffness, and impaired power of action in the wounded structures, after a deeply penetrating wound; but this amount will be very materially curtailed if judicious preventive measures have been adopted and systematically pursued.

CHAPTER IV.

LOCAL TREATMENT OF INJURIES FROM LARGE PROJECTILES.

Contusions produced by heavy projectiles.—I now pass to a consideration of the treatment to be followed in injuries produced by the heavier kinds of projectiles—gunshot, fragments of shell, grape, and others. And before speaking of the open wounds which such masses of metal are apt to cause, it will be well to mention the treatment which seems best fitted for the severe injuries which occasionally result from their impact without any open wound; especially for those accidents which have been previously referred to as 'contusions from the brush of a shot,' or those at one time erroneously attributed to the 'wind of a ball.'

Contusions resulting from gunshot and heavy fragments of shells, when these projectiles have struck a part of the trunk, even though they may not have been accompanied with injury to viscera, and when they have struck a limb, although they have not inflicted mischief enough to make removal of the damaged extremity offer the best chance of safety for the patient, are almost always sufficiently serious in their nature to cause considerable anxiety as to their probable consequences.

In occasional instances these masses of metal, especially when they present smooth surfaces and strike glancingly, produce contusions, the extent and complications of which it is by no means easy even for experienced military surgeons to diagnose with exactness. Hence there is sometimes an absence of proper treatment, and lamentable consequences ensue. In some instances the amount of swelling and rigidity due to the quantity of effused blood constitute impediments to an arrival at a correct knowledge of the condition of deeply seated tissues. In other instances there will sometimes be so little mischief apparent to the sight or touch, so slight an amount of swelling, ecchymosis, numbness, and tenderness on pressure, that from these causes a surgeon may be easily thrown off his guard as to the gravity of the injury which has been inflicted, and not enjoin the necessary care and quiet with sufficient earnestness. The patient, too, will occasionally make light of his injury, from the absence of any marked indications of its severe character; or he may do so from hardihood, or from being reckless

of consequences, and refuse to subject himself to the restrictions and treatment which are really necessary. Thus from some of these causes, singly or combined, the injury becomes neglected at the onset, the time when proper care would have been of most avail. The patient forces himself to remain at his ordinary duty, taking his usual exercise in spite of increasing pain and difficulty, until he is no longer able to move about. Absorption of the effused blood in the ecchymosed parts does not take place, recovery of the injured tissues is prevented, and the final result is that inflammation ending in abscess is excited, or perhaps sloughing follows in some of the deep tissues, eventually disabling the patient altogether for military avocations.

Contusions from missiles of moderate weight.—Slight contusions from fragments of shell of moderate weight seldom give rise to the necessity for any special treatment, although tenderness on pressure, and pain on movement, may remain for a considerable time. The pain, on muscular action, generally forces the patient to rest the contused part as much as possible, and, naturally, restoration to a sound state gradually ensues. It is not to be forgotten, however, that exceptions will occasionally occur as regards immunity from ill results, even in these slighter forms of contusion. Inflammation will sometimes follow in simple flesh contusions, and will go on to suppuration and the formation of abscess; or the effect of the contusion may be concentrated on some nerve, leading, if neglected and further irritated, to persistent pain, even to more or less complete paralysis of the parts to which it is distributed; the surface of a bone may be involved, and circumscribed periostitis originated; or, especially if the ribs and sternum are concerned, caries or necrosis may ensue. In many such cases judicious early care and treatment will be the means of warding off these untoward consequences. Contusions, slight in appearance, of the head from projectiles are often the sources of much trouble in military practice. Not unfrequently, although not producing any of the more obvious morbid conditions which occasionally result from these injuries, they lead to cerebral symptoms which cause soldiers eventually to be discharged from the army; and there is reason to think that, occasionally at least, these results are in some degree to be accounted for by neglect of treatment and care in the early stage of these injuries, owing to the absence at that period of marked indications of gravity. The soldier regarding the blow which he has received in the head as a matter of trifling moment, pursues his usual habits, exposes himself to the sun, perhaps indulges to excess in stimulants. Thus the local inflammation, which under other circumstances might be resolved, is kept up, and slowly, but surely, induces progressive morbid changes which become in the end too firmly established to admit of removal.

The chief indications in the treatment of all gunshot contusions

which are moderate in degree and extent, are the application of cold in the first instance to limit effusion of blood, and to diminish tendency to excess of inflammatory action; avoidance of local weight and pressure: the maintenance of rest in the part injured, as complete as possible, so long as any inflammation or tenderness continues; and when the seat of contusion is near to important viscera, abstinence from all causes calculated to excite and disturb any of the organs in proximity to the seat of injury.

In accordance with these indications the use of ice, when it can be obtained, will sometimes prove very beneficial. At the same time it must be used with caution, especially if the tissues appear to be much contused and injured, lest it lower their vitality so far as to induce mortification. In the absence of ice, evaporating water and spirit dressing, cold irrigation, the subacetate of lead lotion, or any other such cooling applications, may be employed with advantage. When much pain or tenderness on pressure are complained of, and the superficial structures do not exhibit much evidence of contusion, the topical abstraction of blood by leeches, if they can be procured, or by cupping, will afford relief. If, however, the surface be much bruised and discoloured by effused blood, these remedies should not be resorted to, for unhealthy action is not unlikely to follow opening the tissues in this condition. Moderate friction and stimulating applications will often be serviceable for promoting absorption of the effused fluids, and for restoring tone to the injured and weakened structures in the later stages of those contusions in which abscess and sloughing have been escaped from.

Contusions of the walls of the abdomen from heavy projectiles, however trivial they may at first seem to be, should always receive careful treatment. Although no visceral complication, or troublesome effusion of blood in the abdominal wall, may be exhibited, peritoneal inflammation, or parietal abscess, is easily excited when no precautions are taken to avert these accidents, but the patient is unguardedly allowed to follow his usual habits and avocations. It should not be forgotten, too, that there is frequently met with, after these injuries, a tendency to circumscribed muscular atrophy, and, as a further consequence, to ventral hernia. Rest in the recumbent position, keeping the abdominal parietes in a relaxed condition by flexing the thighs on the abdomen, appropriate local applications for moderating inflammation, so long as any pain or tenderness continue at the seat of contusion, together with artificial support of the injured abdominal wall when the patient is allowed to rise and take exercise, are prominent features of the treatment called for in these cases.

Contusions from more massive projectiles.—In the cases in which a large mass of shell striking with its convex aspect, or any other heavy shot, comes into collision with the surface very obliquely and fails to make an open wound, one of two kinds of contusion are

usually presented to the surgeon. In the one, the compression and crushing to which the structures opposed to the projectile have been subjected, are manifest to the sight from the ecchymosis, swelling, and loss of sensation, of the part injured; in the other, these superficial evidences of the damage which has been done are wanting, from the effects of the contusion being more deeply localised. The situation of the part of the body impinged on may determine these differences, or it may be the difference of direction with which the projectile has struck, as elsewhere explained when considering internal injuries without external marks. But certain parts of the body are more favourable for the occurrence of each of these kinds of contusion than other parts. The parts of the body in which bony structures are but superficially covered with soft tissues, are more likely to present the form of contusion in which there is abundant evidence of the severe injury to which the parts have been subjected; in the parts where thick layers of muscular tissues overlie the solid structures—in the nates, for example, the fleshy part of the thigh, or the calf of the leg—the form of contusion, in which little if any superficial mischief is exhibited, while serious crushing exists below, is generally met with. It is to these latter cases that the surgeon's attention requires to be more particularly given, for it is easy to be deceived as to the extent of the damage which has been done in the deep tissues when the inspection of the injured part is hastily or carelessly made.

The first object in all these cases of severe contusion must be to keep the effects of the mischief within the bounds marked by the projectile. Care and proper treatment may accomplish this; neglect or injudicious treatment may readily cause their extension to parts beyond the immediate seat of injury, and, indeed, may allow them to increase till they get beyond control. The chief source of danger after contusions from heavy projectiles, excluding those cases which are complicated with visceral complications, arises from the tendency to the formation of deeply seated abscesses, or the supervention of extensive sloughing. The abscesses may result from inflammatory changes in the injured tissues immediately after the injury, or may occur later, slowly taking the place of effused blood. If blood has been extravasated so as to form a tumour, every effort should be made to obtain its removal by absorption: it should not be opened if the operation can be avoided. The admission of air will only lead to suppuration, and, if the surrounding tissues be much contused, may lead to gangrene. But if a large quantity of blood has been effused, and the swelling resulting from it remains undiminished in size after two or three weeks have elapsed, despite all attempts to obtain resolution of it, it may be treated as an abscess and evacuated in the same way as if it consisted of pus. If allowed to remain untouched indefinitely, it will in all probability excite surrounding inflammation, lead to the formation of pus, and

an extended abscess will result in which the effused blood will be mixed with its other contents. The attempt may be made to evacuate the collection of blood by a trocar and cannula, taking care to arrange the skin so that the opening in it may not correspond with the opening in the fascia after the withdrawal of the instrument, or by an exhausting syringe, and thus to obviate, as far as possible, the admission of air into the hollow space from which the blood has been extracted. If the blood be sufficiently fluid to flow away by these means, as soon as the tumour is emptied a compress and bandage should be applied, so as to maintain a moderate but equable pressure over the part. Sometimes inflammation and suppuration will follow the operation, when a free incision will be required: and if circumstances admit of this incision being practised antiseptically, or in some of the other ways adopted to secure exclusion of air, it should be so made.

In a large proportion of such cases the parts which have received the concentrated impulse of the heavy blow are completely crushed, the tissues within certain limits have their vitality destroyed, and their separation by sloughing is the inevitable result. The surrounding structures are also more or less strained, the degree of injury lessening as the distance from the centre of impact increases. Although the integument may remain entire, the damage it has sustained, and the extent to which it has been deprived of its natural blood supply, will be indicated by undue coldness to the touch and loss of natural sensibility. Sloughing may then be feared to be almost inevitable. If this should occur, the surgeon's duty then becomes to assist nature in the process of detaching the mortified tissues by appropriate local applications. At the same time attention should be given to warding off all sources of irritation from the less severely injured tissues immediately surrounding the principal site of injury, so that the mortification may not extend to them. The strength of the patient must be supported, so that the process of separation of sloughs may proceed as vigorously as possible. Rest, the maintenance of an equable warmth around the seat of injury, the removal of all undue pressure or constriction, and the administration of sedatives to allay pain and procure sleep, are the points chiefly to be insisted upon. In the field, the removal to long distances of patients suffering from these injuries, and their transportation in rough and jolting vehicles, should be prevented as far as circumstances render it practicable to do so. Lint soaked in carbolised oil and covered with some tissue preventing evaporation, or a thick covering of cotton wool lightly secured over the injured parts, are the best means of maintaining an even warmth in their vicinity. Opium in some form is the most valuable sedative medicine for allaying local pain, and preventing the constitutional irritation and exhaustion it would otherwise excite. The diet should be as simple and readily digestible as can be

procured. Everything tending to weaken and depress the patient should be avoided, in order to maintain his bodily powers for the long ordeal he will have to go through. As the sloughs separate, offensive odours and discharges must be neutralised by the usual means, and at this time especially some of the tonic medicines—quinine, the mineral acids and others, the addition of wine or other stimulants to the diet—will be most serviceable. If the contusion be one involving extensively a part of one of the extremities, the question of immediate amputation will have to be considered, and the practice to be followed will be determined by the nature of the structures involved, the extent of the injury, and other special considerations. It is not to be forgotten that in occasional cases, when the integuments have remained entire, such a degree of firmness and solidity of the contused portion of the limb will result from the distension of the subjacent tissues by the blood poured out among them, that even the existence of comminuted fracture of a bone may at first be overlooked; and that in all cases, under such circumstances, the exact amount of destructive crushing effected will be very materially masked. The accompanying symptoms will rarely, however, leave a surgeon in doubt as to the gravity of the nature of the case when it is really one in which the performance of amputation is called for.

Open wounds produced by heavy projectiles.—The large, lacerated, and extremely contused, open flesh wounds produced by gunshot, or by fragments of shell striking forcibly soon after explosion, are generally of a directly fatal character, or, being situated in one of the extremities, require immediate amputation. But when they are of such a nature as to offer a fair hope of cure under treatment, they demand unremitting and prolonged attention on the part of the surgeon. The general principles of the treatment must be as follows: After all loose disintegrated tissues, torn shreds of cloth, or other foreign bodies, and clot, are lightly and carefully cleared away, the margins of the wound should be supported by the most appropriate means available, according to its position, shape, and extent. All unnecessary pressure, all constriction, should be carefully avoided in applying this support: its object is simply to relieve the bruised and weakened tissues of the strain which would otherwise result from their own weight.

When the fragment of shell has passed superficially for some distance beneath the integuments, so as to have caused a bag-like wound in which sloughs are not unlikely to remain pent up or pus to collect, incision of the surface, so as to lay the contused wound open before applying the dressings, will facilitate the healing process.

If the skin has been peeled off to some extent, so that it has become a loose flap, it should be carefully replaced in its normal relations to the parts from which it has been detached, in the hope

that much of it may retain its vitality, and again form their natural covering: and in like manner, when muscular tissues have been torn from their natural connections, they should be carefully restored to their former situation, no part being cut away which is not manifestly so crushed as to be deprived of all vitality. A few sutures may be employed if absolutely necessary to retain together the parts which had been torn asunder; but it is much better to abstain from using them on such occasions, if any other means can be found to keep the lacerated tissues properly approximated to each other. If the patient is not about to be removed to some other hospital, but can remain quietly at the place where the wound is being dressed, some strips of lint, soaked in the serum oozing from the wound, applied at the necessary spots, together with the other usual dressings and sustaining bandages, but, above all, appropriate position of the limb or part of the body in which the wound is situated, will generally answer the objects aimed at. The common diachylon plaister is objectionable on account of the local excitement to which it frequently gives rise; sometimes causing inflammation of the surface to which it is applied, which assumes more or less of an erysipelatous character. Rest, as complete as practicable, of the wounded part of the body is to be maintained in order to prevent irritation of the injured structures. To protect the exposed surface of the wound from the influence of the air, and to maintain warmth in it and in the surrounding parts, the most suitable application for military hospitals is lint soaked in carbolised oil covered with oiled silk, or some other impermeable cloth of a light kind. As the sloughs are thrown off—and there will always be a certain amount of tissues deprived of their vitality which have to be separated from the less severely crushed parts in grave wounds caused by heavy projectiles—the sore has to be treated in the same way as all other cases of traumatic gangrene. The surgeon must be on his guard against the complications, local and constitutional, which may readily occur in such cases. The support and maintenance of strength, and the relief from pain by appropriate remedies—points elsewhere dwelt upon—are of the greatest importance in these injuries, which are almost invariably tedious in their progress, requiring prolonged hospital treatment, and trying the constitutions of the patients to the utmost limits of endurance.

The amount of substance which is often lost in these injuries, whether primarily removed by the projectile itself, or by gangrene as a result of the crushing to which the parts have been subjected, is rarely replaced under any conditions of treatment, so that a depression or gap, more or less deep according to the nature of the wound, remains. The process of cicatrisation is accompanied with adhesions of superficial to deeper parts, and a certain amount of contraction of the surrounding tissues, involving greater or less

interruption to the normal functions of the limb or part of the body injured. The amount of interference, produced by the manner in which cicatrisation takes place, may often be modified by judicious arrangements on the part of the surgeon according to the situation of the injury. Due consideration must be given to the adhesions and contractions which are likely to occur during the treatment—when placing an excavated superficial wound in a position of rest, when arranging a deeply-tunnelled wound on its pillow, when applying supports, and making other such local arrangements. The surgeon should take care that the position and modes of support which he selects are such as will best conduce to repair being accomplished with least impairment of the functions of the organs with which the wounded parts are associated. When the healing process is completed, the thin and easily ulcerable cicatricial integument which has been formed will generally require to be protected by some appropriate covering to shield it against accidental injury.

CHAPTER V.

DESCRIPTION OF INSTRUMENTS EMPLOYED FOR THE DETECTION AND EXTRACTION OF FOREIGN BODIES LODGED IN GUNSHOT WOUNDS.

I have explained the general principles on which the exploration of wounds is made for the detection of lodged foreign bodies, as well as the ordinary means employed for the purpose, in the chapter on the local treatment of wounds after the arrival of the patients at a field-hospital. It was then mentioned that in certain cases the use of special instruments becomes necessary to determine the question whether such foreign substances are or are not lodging in wounds. The present chapter contains a description of the exploring instruments which have been employed in such cases.

The usual modes of extracting foreign bodies from wounds, after their lodgement has been discovered, were also described in the chapter on local treatment of wounds. It was considered more convenient, however, to postpone the particular description of the instruments employed for the extraction, and it will now be given.

The remarks in the present chapter will thus embrace, (1) a description of the special instruments employed in particular cases for the detection of lodged foreign bodies in wounds; and (2) a description of the instruments employed for their extraction.

(1.) *Exploring Instruments.*

Exploring instruments for cases of lodgement presenting special difficulties.—It has been already mentioned that in the majority

of cases of gunshot wounds there is no difficulty in detecting foreign bodies which happen to be lodged in them, especially such heavy substances as bullets and fragments of shell, when an early search has been made for them by the finger or by the long silver probe. The instruments now to be described are only intended for cases in which the exploration by the surgeon's finger is altogether impracticable, and in which the use of the probe is attended with so many sources of doubt as to prevent any satisfactory conclusion in respect to the lodgement or absence of foreign bodies from being arrived at. These difficulties sometimes happen in situations where they might least be expected to be met with, but generally occur with such wounds as have their terminations at or near some of the solid structures of the body. They are every now and then experienced in recent wounds, especially deep and narrow wounds made by small-bore rifle or pistol shot; but are more often encountered in chronic wounds in which foreign bodies are suspected to be lodged—wounds in which the original bullet tracks have become contracted to narrow sinuses, and in which other changes have taken place rendering the directions of these sinuses tortuous or otherwise intricate. The finger may not be able to penetrate the small and constricted passage of such a wound; and the probe, even if it be enabled to traverse it, and happen to reach a hard substance, may fail to give the desired information as to its nature —whether it is striking against bone, or the foreign body which is suspected to be lodged.

It may be readily ascertained by striking or rubbing a leaden bullet out of the body with a silver probe, and comparing the peculiar dull sensation conveyed to the fingers with the sensation experienced when a piece of bone is struck or rubbed, that the differences between them are so marked, one cannot under such circumstances be deceived, even with the eyes shut, as to the respective qualities of the two substances. But when the bullet or piece of bone is at the bottom of a wound, and the probe comes in contact with the side of the wound, especially if this side happen to be bone; or if the walls of the track be fleshy, and, while the probe is in contact with them, its extremity is pressed against bone which has become smooth and eburnated on the surface; or if any soft tissues intervene between the end of the probe and the object impinged upon by it; it will be found that such a complicated sensation is given to the fingers that the diagnosis is rendered exceedingly difficult and uncertain.

No more remarkable illustration of the difficulty of diagnosis just adverted to could be adduced, perhaps, than was afforded in the instance of the wound received at Mentana by General Garibaldi. In that case, the opening presented to the surgeon beneath the integument consisted of a fissure across the base of the inner malleolus. This fissure was not wide enough to admit a finger; and

ordinary probes, when inserted, so failed to give satisfactory evidence on the important question of a foreign body being impacted in bone near the ankle-joint, that some of the ablest surgeons in Europe, after exploring with them, were led to declare that no bullet or foreign body had become lodged in the wound. And this occurred in a case where the opening made by the projectile was not much more, if any more, than an inch in depth, in which the track was not tortuous, nor among tissues of different kinds or of intricate arrangement, as frequently happens in doubtful cases.

FIG. 30.

Nélaton's Probe.

Nélaton's probe.—M. Nélaton, after his visit to General Garibaldi, felt assured that the bullet was lodged in the wound, and was led to think of various devices for obtaining demonstrative proofs that his opinion was correct. His first idea was to obtain a steel probe cut like a file at one extremity. He presumed that by passing such an instrument down to the substance which he suspected to be the bullet, and by giving it a rotatory motion, sufficient would be brought away on the teeth of the file to determine its nature. At the same time that he was having this instrument made, he reverted to the idea of a chemical reagent, which had been tried before in similar cases of doubt, but without success.[26] Acting on this notion, M. Nélaton applied to M. E. Rousseau, the well-known chemist, to furnish him with some simple means of determining the presence of lead in a wound by chemical analysis. M. Rousseau then suggested the introduction of a body capable of bringing away a metallic impression should metal be present, such as rough porcelain; thus making the metal capable of being recognised not only by chemical reaction but by its ordinary physical signs. This suggestion led to the construction of the instrument which, since its successful application in Garibaldi's case, by Professor Zannetti, of Pisa, to whom it was sent by Dr. Nélaton, has become known as Nélaton's probe.

Nélaton's probe (fig. 30) consists of a slender rod of metal, five or six inches in length, terminated at one end by a small knob of white, unglazed, biscuit china. The other extremity of the probe is furnished with a small handle, grooved ridge-and-furrow fashion, in order that the finger and thumb may the more easily roll it between them, while the porcelain knob is being pressed at the bottom of the wound against the suspected foreign body. If it be a leaden bullet against which the porcelain is rubbed, a very distinct mark of lead, which is not easily obliterated, is impressed on it. The bullet itself is thus caused to give ocular demonstration of its presence and place of lodgement. If the foreign body be

iron, having a rusty surface, a stain of rust will be found on the china.

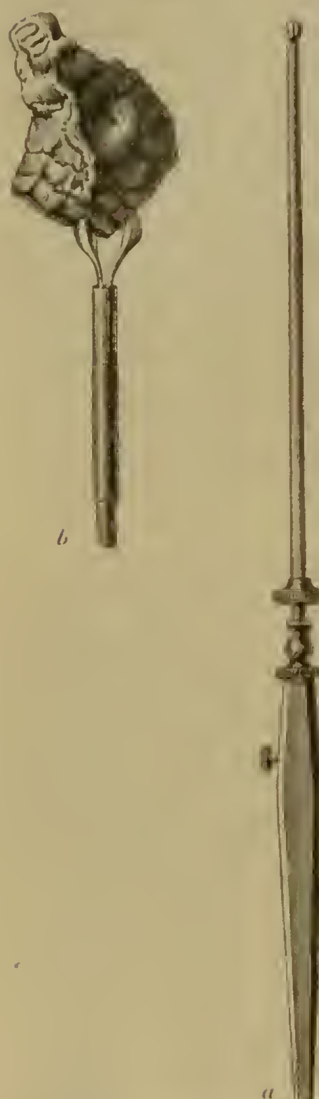
The round ball of china which is fitted to the Nélaton test-probes usually has a diameter of rather more than a quarter of an inch. This is often large enough to cause a difficulty in introducing it through a small fistulous track among fibrous tissues, which is frequently met with as one of the chronic effects of gunshot wounds. A sinus of this kind, unless connected with necrosed bone, usually leads to suspicion in the mind of the surgeon that it is prevented from becoming completely closed by the lodgement of some foreign body which passed along it at the time of the original wound. It is, therefore, just one of the cases in which such a test-probe offers itself as a valuable diagnostic aid to the surgeon, but the size of the round knob too often interferes with the attainment of this object. A probe tipped with a piece of the biscuit china of less diameter, and more oval in form, is required for these narrow fistulous tracks. In a recent wound, the larger round ball is more convenient. It is not so likely to be impeded in its passage along the wound, and the impression made by the lead upon it is more obvious to observation.

It is evident, from the nature of the porcelain test-probes just described, that direct and firm contact between the porcelain and a bullet is essential, in order that the former may furnish the evidence which the surgeon requires. If it be merely a little blood, serum, or soft coagulum, in front of the bullet, pressure by Nélaton's probe will squeeze it away, and the leaden mark can be obtained; but if any resisting medium, however thin—the thinnest membrane, for example—happen to be placed between the surfaces of the metal and the china, no impression will be made on the latter. And there are various substances which are liable to be so interposed—such as muscular or cellular tissue pushed by the knob of porcelain itself before it; pieces of linen, cloth, paper, or other substances which have entered with the bullet; a piece or edge of bone projecting in front of it, and other such obstacles. The evil in such an occurrence may not simply be the impediment to obtaining an impression from the lodged bullet; but possibly a surgeon may be led to an erroneous conclusion that he has obtained proof of no foreign body being lodged, because the usual evidence of its lodgement is absent from the porcelain. This may cause delay in the healing process, and protracted suffering to the patient, all of which might have been avoided had a more correct diagnosis been arrived at.

Lecomte's stylet-pince.—To obviate these difficulties and sources of fallacy, a surgeon of the French army, Dr. Lecomte, invented an instrument, to which he gave the name of 'probe-nippers' (stylet-pince). His design was not merely to indicate the presence of a leaden bullet, by bringing away a stain or mark of its presence,

but by bringing away a small portion of the lead itself. Such an instrument could not only be used for bringing away a scale of lead, but also a minute portion of paper, cloth, wood, or any other foreign body capable of being cut in a similar manner. If the supposed foreign body were a fragment of bone, it would equally bring away a particle of it. It was evident that, in addition to its other qualities, the stylet-pince would require to have its nippers smaller in size than the porcelain knob of Nélaton's probe, with a stem of sufficient length to be passed along narrow sinuses, and at the same time solid enough to bear a certain strain in use.' I have sufficiently ascertained by experience that the stylet-pince does possess the qualities aimed at by Dr. Lecomte.

FIG. 31.



Lecomte's Stylet-pince. (*a*) the curettes closed, (*b*) the curettes open and grasping the edge of a deformed bullet.

The instrument consists of two portions. The first is a central steel rod of small diameter, fixed in an ivory handle at one extremity, and cleft at the other into two small branches, each of which terminates in a little cup-like blade or curette: the second is a slender cannula, which glides backward and forward, but only within a limited distance, along this rod. The central rod is fixed in the handle by means of a side-screw, which can be loosened at pleasure by the surgeon, so as to increase the length of the exposed part of the stem, or to enable it to be removed altogether to be cleaned. The two steel curettes have very fine and sharp edges. They separate from each other by the elasticity of the two little steel branches, of which they are the terminations; but they are easily brought together by a slight pressure, such as that exerted by causing the cannula to glide along the central stem up to them. When they are thus brought together, the two curettes so fit one to the other that, united, they form a small smooth steel knob or rounded extremity, about one-third of the usual size of the china knob of a Nélaton probe.

It will be apparent, from the description, that the gliding of the cannula determines the opening and closing of the curettes: when it is slipped back, the curettes open; when it is pushed forward, they are closed, and form a little hollow globe. There is no

difficulty in the manipulation of the instrument. It is inserted with the curettes closed, and it may be used then precisely as the long silver probe in a surgeon's capital case of instruments. When about to be employed for determining the nature of the substance with which it is put into contact, the cannula is drawn towards the surgeon, at the same time that the extremity is retained with an equable and steady pressure against the substance. This movement has opened the curettes. The same even pressure is sustained while the cannula is pushed home, and this causes the curettes to be brought together again; their edges, as they close towards each other, nipping off a small particle of the substance over which they are moved. The instrument is then withdrawn, and, supposing it to have been brought into contact with an ordinary bullet, a small scale of lead will be brought away enclosed within the cavity of the rounded extremity formed by the two curettes. The glistening surface of the freshly cut shaving of lead will sufficiently indicate its nature. If any difficulty should occur in distinguishing the particle which has been brought away, it can be removed from the curettes, and observation under an ordinary magnifying lens will show what the substance is. The stylet-pince is thus a most useful explorer for deciding doubtful cases of lodgement of foreign bodies; it responds as an indicator with even more distinctness than the Nélaton probe in all cases in which that test would be of service, while it answers for a variety of other cases in which the Nélaton probe would give no indication at all.

Electric indicators. Electricity was some years ago suggested as a means of detecting lodged bullets and other metallic substances in wounds; and some very ingenious appliances depending on this agent have been lately contrived for the same purpose. One of the first to experiment upon an electric apparatus of this kind was a French military surgeon, M. Fontan, who derived the suggestion from Professor Favre of Marseilles.[27] Two insulated conducting wires ending in steel points, were connected with a small galvanic battery. One of the wires was in communication with a galvanometer. When the points were caused to penetrate the surface of a piece of metal lodged in a wound, the circuit being completed, the needle of the galvanometer was deflected. An instrument of this kind was used in Garibaldi's case, but, by some mishap, the two points were not brought into contact with the lodged bullet, and no indication of its presence was obtained.[28]

The improvements which have taken place in the modern applications of electricity have paved the way for more simple, and yet more sensitive, bullet-explorers. One of these is the invention of Mr. De Wilde, a civil engineer, and is very compactly arranged in a box of small dimensions. The electric action is excited in a suitable cell, and is increased in intensity by the intervention of a multiplying coil. A special exploring probe is connected by in-

sulated wires with the apparatus, and the indication, when the circuit is completed by contact of the two points of the probe with a leaden bullet or piece of iron, is given by the striking of a hammer against an alarum-bell. The bell sounds at each interruption and renewal of contact of the points with metal. The exploring probe consists of a long slender tube of smooth vulcanite, containing two insulated needles, the points of which can be withdrawn within the tube, or be made to protrude, at the pleasure of the operator. Altogether it is an effective appliance as an exploring instrument, owing to the strength of the electric current developed, and the marked manner in which the indications are given by the sound of the bell when a bullet or other metallic substance is met with. There is also attached to the instrument a bullet-extractor, the two arms of which are insulated, and so arranged that, when they are connected with the battery, in the same way as the explorer, they indicate the grasping of the foreign body similarly by the sound of the bell. Unless the metal be firmly grasped by both blades, without any other substance intervening, the indication will not of course be given. M. Kovacs, a Hungarian physician at Pesth, and Professor Neudörfer, have designed somewhat similar instruments.

Another electric instrument has been made by Messrs. Krohne and Seseman, of London. The indications of contact with a lodged bullet or other metallic substance are afforded in this instrument by the movements of a fine needle working upon a dial-plate, in the same manner as is seen in the ordinary single-needle telegraph. Attached to the instrument are not only an insulated bullet-extractor and explorer, but also a pair of acupuncture needles adapted for use in cases where metallic bodies are supposed to be lodged in soft tissues, away from any means of approach by an open wound or sinus.

Both De Wilde's and Messrs. Krohne and Seseman's electric indicators have been used with advantage in the wards at Netley, but the latter has proved to be the least liable to get out of order. In one case a patient had been wounded in the outer part of the thigh by a bullet two years before admission. There was no wound of exit. The wound had healed in due course without the bullet having been found. On his admission a small fixed tumour was felt in the upper part of the ham, deeply placed between the hamstrings. There was nothing to give assurance that it was the bullet, but, on passing down the two fine needles of Krohne and Seseman's electric apparatus, the necessary proof of its being a metallic substance was at once obtained. The extraction, which was rather difficult from the place of lodgement and the firm manner in which the encysted, and, as it proved to be, deformed bullet was connected with the surrounding tissues, was proceeded with without any hesitation after the information gained. A soldier.

who had been wounded in the Ashanti war in the upper part of the right ear, and adjoining part of the head, suffered from frontal headache, especially on the right side. The wound was soundly healed. On the right temple, not far from the scar of the wound, a diffused hard swelling was felt. It was fixed, smooth on the surface, and without any defined edge. It was suspected it might be some lead spread out over the bone. Two needles were successively passed, as in the case before mentioned, and the electric indicator decided the question. An incision being made the flattened lead was extracted. In another case, in which a man had been wounded in the thigh in the Ashanti war and the shot not extracted, though the wound had healed, a hard nodule was found and the needles passed down to it. It was felt to be a foreign body, but the electric indicator gave no sign of metal in this case. It had been previously ascertained that the nodules of iron-stone, sometimes used by the Ashantis for projectiles, had not the power of deflecting the electric indicator, and the substance was therefore suspected to be one of them. On extraction it proved to be an iron-stone slug as supposed.[29]

A rough but sufficiently effective electric instrument for facilitating the discovery of metallic substances lodged in gunshot wounds can be made in the following way. The magnet of an ordinary pocket-compass, which has had some turns of wire covered with thread wound round it as an induction coil, is employed for the electric indicator; while a piece of copper sheeting, bent round a small plate of zinc, but separated from it by flannel padding saturated with the usual diluted acid, forms the voltaic pile. The exploring instrument is formed by two insulated wires, bound together, but with the points left free. When these parts are connected, and the circuit is completed by contact with metal, the indication is given by movement of the magnet of the compass. Dr. Althaus refers to a very simple contrivance of a similar nature by Dr. Oscar Liebreich, of Berlin.

Endoscopic exploration.—Lastly, the endoscope has been suggested for use in exploring for foreign bodies in wounds. Dr. Fenger, of Copenhagen, in 1869 made some experiments with the instrument on horses, and came to the conclusion that pieces of cloth in wounds, or bullets driven into bones, could be seen by its means.[30] Dr. Fenger has stated that he was enabled in several instances during the late Franco-German war, on examining wounds some weeks after they had been inflicted, to see their interiors distinctly by means of the endoscope, without causing pain, hæmorrhage, or any subsequent irritation, in consequence of the introduction of the instrument.

(2.) *Instruments for the Extraction of Foreign Bodies from Gunshot Wounds.*

Three different classes of extracting instruments.—The instruments devised for extracting missiles and other substances which are liable to become lodged in gunshot wounds are exceedingly numerous. The greater number of them, however, although differing in particular points of detail, may be classed under one or other of three mechanical contrivances, viz.:—(*a*) the Forceps; (*b*) the Scoop; and (*c*) the Screw. Some composite forms of bullet-extractors consist of a combination of two, while a few comprise all three, of these appliances. It will be useful to give a brief account of some of the instruments in each of the three classes, selecting those which possess special features or have been designed to meet special wants.[31]

(*a.*) **Bullet-extractors of the forceps class.**—This class contains the greatest number of varieties of instruments. They differ chiefly in the shapes of the blades, their modes of grasping, the manner in which the grasp of the foreign body when caught between the blades is secured, the methods by which the stems are connected, the length of the stems above and below their point of juncture, and the extent of separation of the stems necessary for getting the foreign body between the blades. The following seem to be the requisite qualities of such an instrument. The shape of the combined blades should be such as to enable them readily to embrace the forms of bullets in ordinary use, and at the same time such as not to interfere with their capability of taking hold of bodies of more irregular shapes. The stems should be so connected, and of such length, as neither to stretch injuriously the contused tissues of the wound during their insertion, nor at the time of being opened in trying to grasp the body which the operator is searching after; and, lastly, there should be means, when once a foreign body is got between the blades, of holding it there securely, so that it may not be liable to slip, or be drawn away, during the process of taking the instrument out of the wound.

The ordinary dressing forceps in the surgeon's pocket-case of instruments, is an example of an extractor of this class; indeed, it is very commonly employed for removing bullets which have lodged superficially, whether near the wound of entrance or after being exposed elsewhere by incision. But it is only a suitable extracting instrument when a foreign body is very near the surface. The dressing forceps should not be employed if a bullet is lying deep and out of sight. Its blades are not fitted for holding securely bodies with smooth and convex surfaces; and the stems are so hinged together, that, if they are inserted deeply, they become hurtful, by reason of the distance between them when they are opened for the purpose of trying to grasp the foreign body, and,

consequently, by their distending and bruising effects on the neighbouring tissues.

Old pattern bullet forceps. — This instrument, which was formerly supplied in army instrument cases, had small round excavated blades, such that when a spherical bullet was caught between them, they partially closed over it, and so held it within their grasp. The stems, which were much bowed outwards, were connected by an ordinary fixed hinge. This was placed at a short distance, two inches, from the curved blades. The stems were thus divided into two short arms between the hinge and the blades, and two long arms, each five inches in length, between the hinge and the handles. The ill effect of this arrangement was that in order to separate the blades sufficiently for seizing a bullet, the long and bowed arms connected with the handles of the instrument had to be widely separated, and the wound of entrance, and the adjoining track of the bullet through which the forceps had been passed, were subjected to distension of a very mischievous character. These inconveniences became aggravated in proportion to the time occupied, and to the movements made, in searching for the precise site of lodgement of the foreign body, and in the endeavours to grasp and remove it — operations which it is not possible to prevent from being protracted in occasional cases. The defective form of the bullet forceps of the old pattern, especially in respect to the position of the hinge, is found to exist in not a few instruments of comparatively recent construction.

Evans' old pattern bullet forceps. — The stems were differently arranged in this instrument in respect to the hinge. The arms which terminated in the blades were the long arms, being five inches in length, while the handles were only three inches long. They distended the track less, but were deficient in grasping power; but their chief difference consisted in the addition of a steel spring, which was placed on the inner surface of one of the handles in such a way as to work against the corresponding face of the opposite handle. This enabled the instrument to be used by one hand alone, leaving the other hand of the operator free. It, however, kept the blades apart at all times when the handles were not pressed towards each other, and the instrument was thus rendered inconvenient for package.

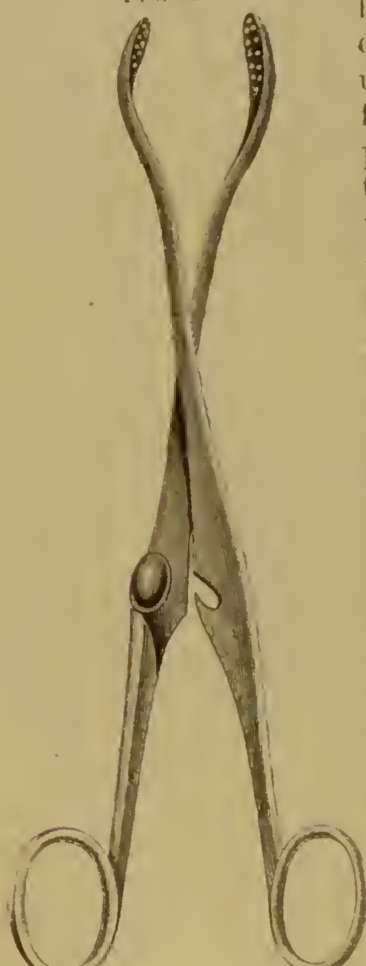
Ferguson's spring bullet forceps. — In this forceps the spring is hinged in the middle, so that it can be folded up. It only acts against the face of the opposite handle after it has been opened for the purpose. When the spring is folded, the two stems of the forceps remain in close contact. The blades are narrow, elongated, and deeply serrated at the edges, so as to increase their grasping power. The handles are roughened on the outside, and are made on the same plan as the handles usually supplied with tooth forceps.

Weiss's cross-action forceps.—In this instrument the stems are straight at the handles, but are made to cross each other as the blades are approached. The arms of the instrument below the hinge open less widely, in consequence, when they are used for grasping a foreign body.

Read's forceps.—The stems are more curved in this instrument, but they have the same cross action as the one previously named.

Midwifery-hinge bullet forceps.—The injurious distending effects of the action of some of the bullet-extractors just described, when used for trying to grasp foreign bodies in wounds, caused a forceps of different construction to be devised for use in the British army. Instead of the fixed hinge, a hinge similar to the one employed in midwifery forceps was adapted to the instrument. The principle as applied to bullet forceps was not new. It existed in the celebrated triple bullet extractor, or tribulcon, invented by Baron Percy, and he himself referred the idea to Maggius, a surgical author who wrote in the year 1548. By the division of the forceps into two parts, one stem could be first inserted, and, after insertion, could be used both as an explorer for finding the bullet, and as a director for the second blade, to extract it after its site had been satisfactorily determined. As soon as the two stems came into proper juxtaposition, they became firmly connected with each other, both in separating the blades for grasping, and also in withdrawing the instrument, so long as the rings or handles by which the operator held the instrument were kept in proper relation to each other.

Fig. 32.



Midwifery hinge Bullet Forceps.

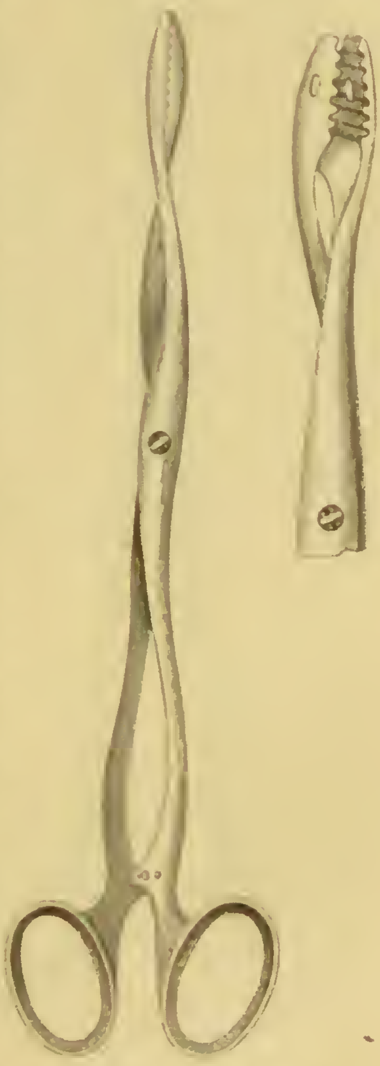
The hinge in this forceps, instead of being near the blades, is placed near to the handles. The long arms of the stems, 6 inches in length, are between the hinge and the blades; the short arms, $3\frac{1}{2}$ inches in length, are between the hinge and the handles. The blades are curved, hollowed, and rasped on their inner surfaces, but the excavation is more oval in form than in old instruments so as to adapt them for receiving conoidal projectiles within their grasp. They meet at their extremities and are thus fitted for laying hold of bodies of irregular shapes, or of larger size

than can readily be received within the blades. This midwifery-hinged bullet forceps is still one of the authorised instruments included in army cases of capital instruments.

Pratt's bullet forceps.—The stems of this forceps are made separate, and arranged to be joined together in use on the same plan as the forceps last described. The blades are rasped at their margins, and are furnished with oval openings at their centres.

Weiss's ball and socket bullet forceps.—The same object that led to the construction of the midwifery-hinge forceps has been sought to be attained by a different mechanical arrangement in this forceps. Instead of having a divided hinge for locking, one stem is made with a small spherical enlargement or ball, the other with a hollow socket in which the ball can revolve. The ball and socket of the respective stems are placed at a distance of $3\frac{1}{2}$ inches from the handles, 7 inches from the blades. The socket stem is deeply grooved from the socket to the blade. The ball stem is round, solid, and can be received into the groove of the socket stem, at the same time that the convexity of its blade is received into the concavity of the opposite blade. The two stems can thus be inserted together, and act as a simple sound. If a foreign body be reached, the ball stem can be turned round and the concavities of the two blades be brought opposite to each other for grasping. A screw-pin enables the ball to be fixed in the socket. It requires practice to manipulate this instrument with adroitness and sufficient firmness.

FIG. 33.

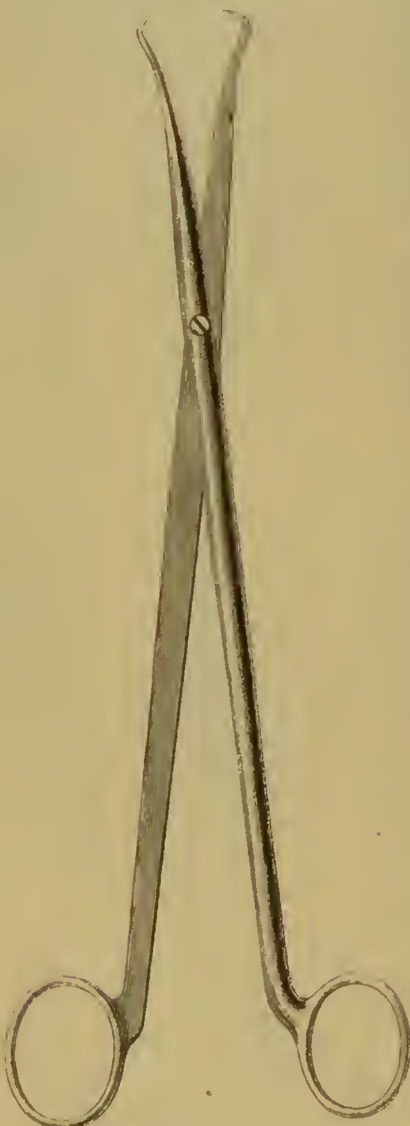


French army Bullet Forceps.

Bullet forceps in use in the French army medical service.—This forceps consists of separate stems, so that one can be used as a sound. One stem cannot be used as a guide to the other, as may be done with the midwifery-hinged forceps, for, to lock them, they must be placed nearly at right angles to each other. Each stem is 5 inches in length from the handle to the joint, and 3 inches from the joint to the blade at its extremity. The blades are oval, and each has a small aperture in its centre. Their edges are deeply serrated. Each stem is slightly curved in opposite direc-

tions before and behind the hinge. The portions of the stems to which the blades are attached work with a cross action, and thus distension of the bullet track is avoided as much as possible. After a foreign body of moderate dimensions is grasped the two stems of the instrument can be pinned together near the rings or handle. For this purpose each stem is enlarged just below the handle, and from this enlarged part a short pin projects in one, while two holes at different distances for receiving it are bored in the other. When pinned together the foreign body is fixed in the grasp of the blades, independently of the operator's hand. This forceps is well designed, strong, and handy.

Fig. 34.



Tieman's Bullet Forceps.

Tieman's bullet forceps.—A bullet extractor belonging to the class of forceps instruments, but different in design from any of the kinds previously described, has been manufactured by Messrs. Tieman, of New York, and has been greatly praised by some surgeons. It corresponds exactly with the sharp-pointed bullet forceps made by Luer of Paris: the only difference being that in Luer's instrument an additional provision is made for fixing the arms tightly together after the teeth are imbedded in the bullet. The arms of this forceps are straight, slender, and joined by an ordinary hinge; but, instead of having broad hollow blades, they terminate in two curved pointed extremities, 'long and stout teeth,' which, when closed, overlie each other in such a way as to present a smooth and blunt surface to any object with which they may be brought into contact. When the curved points are separated, they are adapted for biting into any substance which may be placed between them. Mr. Redfern Davies, of Birmingham, particularly called attention to this forceps in an article in the *British Medical Journal* of May the 28th, 1863, and testified, from his practical experience in America, to its efficiency in easily removing leaden bullets impacted in bones. Mr. Redfern Davies writes: 'However deeply or firmly a leaden bullet may be driven into a

bone, a sufficient space for its teeth to hold by is created by the mere passage of the bullet. It will seize upon and hold a leaden bullet when even a quarter of it is within its grasp.'

One of the favourable qualities of this instrument is thus described: 'By opening it, the curved points have another advantage, in pushing aside from the bullet any blood-vessel or nerve which may present itself, insuring it against all injury from the points themselves.' But it is evident from the nature of this instrument that the surgeon must be well assured, before traction is made, either by actual sight or by other evidence, that the instrument has only the bullet in its claws: that no organised tissues are included, supposing it to be used in extracting a bullet lodged in soft tissues. Although the points may push aside such structures as blood-vessels and nerves when they are in the act of being opened, this offers no security against these structures being pierced as the sharp points are brought towards each other again, or as the instrument is moved about, in the efforts to fix them into the supposed foreign body; nor even, when the points are imbedded in the bullet, against tissues being hooked inwards and held within the space included between the bullet and the short arms of the instrument. The observations made of it at the Army Medical School, when put into the hands of novices for practising the extraction of bullets from the dead body, have shown that, on efforts being made to grasp the bullet, the teeth of the instrument are extremely liable to bite into any tissues which may come in their way, and that, too, without conveying any perceptible sensation to the hand that they have done so. The penetration of the tissues is only made known, indeed, when traction is made upon them in the process of withdrawing the instrument from the wound or by subsequent inspection. Moreover, frequent mistakes were found to be made in the conclusions arrived at respecting a foreign body having been grasped between the teeth, especially when the position of the object sought for was one of much depth in muscular tissues. Its penetrating power, and firm tenacity of grasp, when the instrument is applied to a leaden bullet fairly exposed to view, were proved beyond doubt; qualities which will, in occasional special cases, cause the instrument to be extremely serviceable. For general purposes, in cases of ordinary lodgement, and especially in unpractised hands, the use of such a sharp-pointed extractor hardly seems desirable: for injury can be much more readily inflicted by it, and much more unconsciously to the operator, and can be less guarded against, than is likely to happen with extractors terminating in blunt, smoothly-rounded blades. When employed for extracting a bullet imbedded in bone, the addition of the fixing appliance attached to Luer's sharp-pointed forceps is calculated to be useful: the hand of the operator is left more free for any manipulation that may be required.

Three-bladed forceps.—Grasping instruments have been constructed with three instead of two claws. Some of them are of ancient, some of modern invention. The 'Alphonsinum,' invented by Alphonse Ferrius early in the sixteenth century, was an instrument of this character; and several others with triple claws are figured in old works.

Ruspini's bullet extractor.—In 1813 Mr. Ruspini published an account of his instrument for extracting balls from gunshot wounds.[32] It was said to have undergone the test of repeated experiments, and eminent surgeons in London testified to its great advantages in practice. The object of the instrument was stated to be in the first place to act as a probe, and secondly, to do away with the necessity of enlarging the openings of wounds either by incision or dilatation. It consisted of a silver tube, to the extremity of which three claws, each two inches in length, were attached by hinges. The claws, when closed together, formed a smooth conical end to the instrument. The claws were capable of being separated from each other by three short springs, which were acted upon by a screw near the handle, and a rod passing through the tube of the instrument. The same rod, on a foreign body being included in the grasp of the claws, could cause them to close together upon it. For balls taking a circuitous course Mr. Ruspini prepared an instrument of a similar nature, but rendered capable of following the ball in its track by being made flexible.

Ruspini's bullet extractor was issued for use in the army for many years, but has long fallen into disuse from practical experience of its inefficiency. The idea has been frequently repeated in subsequent inventions. It was rather complicated in construction and liable to get out of order, and evidently was not capable of drawing out a projectile, even though it had succeeded in grasping it, if there were much opposition offered to its removal by the surrounding tissues. The levers by which the blades were opened were very short and weak, and no further power could be brought to act upon the blades than that which was obtained from them.

Goodchild's bullet extractor.—This is a steel three-bladed forceps, invented by Dr. Goodchild, Surgeon of the 1st Warwick Militia Regiment. It resembles Ruspini's forceps before described in consisting of a cannula and central stem worked by a screw at the handle, but differs from it in the mechanical means by which the blades are opened and closed. Instead of the short and slight springs by which the opening of the blades in Ruspini's is effected, the opening of Goodchild's is obtained by the action of the central rod and screw together with the elasticity of the blades themselves; while the closing of the blades is effected by the action of the screw in the opposite direction, so that the blades are drawn together into a tube or cannula. The blades or claws are two inches in length when fully expanded, and can be drawn one inch into

the cannula by the screw action. The *grasping* power of Goodchild's instrument is thus rendered much superior to Ruspini's, and the construction being less complicated, it is less likely to get out of order.

(*b*.) **Bullet extractors of the scoop class.**—Scoops are employed with a view to remove bullets by lifting them out from their place of lodgement, rather than by grasping and then exerting traction. The position of the bullet being fully ascertained, the scoop is passed behind it, and being carefully drawn out again, the bullet is brought away lying in front of it. Some surgeons consider the scoop a safer kind of appliance than instruments that act by grasping; and also that, when once in front of a scoop, a bullet is less liable to slip away during the extraction than another one which is held by pressure on two of its sides between the blades of a forceps.

Ingenious mechanical contrivances have been applied to bullet scoops with a view to facilitate the passage of the instrument along the wound by keeping the scoop, or spoon part of the instrument, in line with the handle until the bullet is reached, and then giving the necessary position to the scoop to enable it to turn behind it. Weiss's and Tufnell's bullet scoops are examples of different contrivances for this purpose.

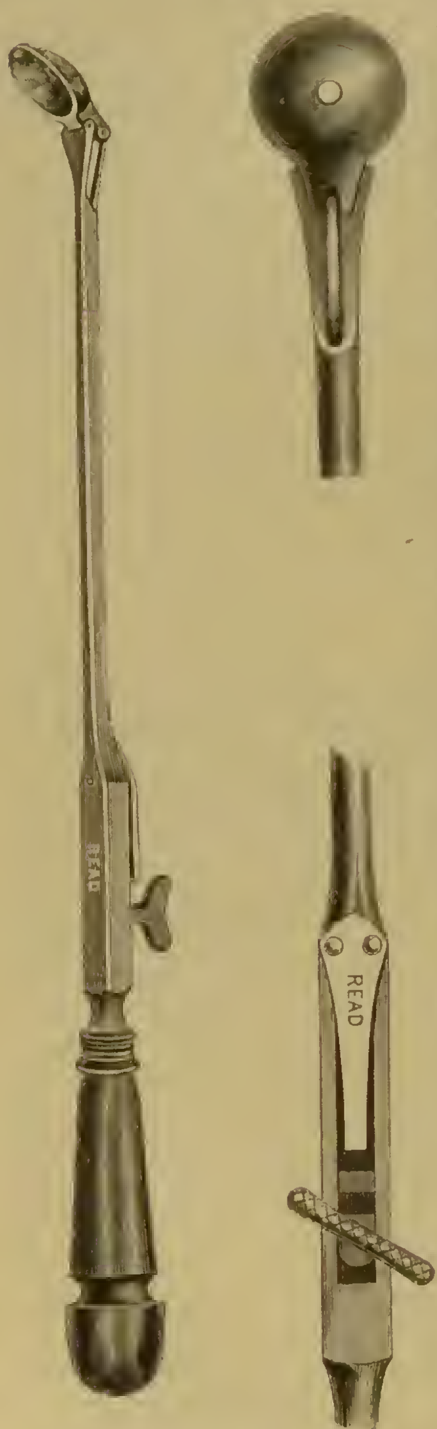
Simple scoops.—Ordinary bullet scoops consist of slender steel rods flattened in the centre and terminating at each extremity in a spoon-like scoop, the concavity of which is rasped to ensure a better hold. Scoops are made of different lengths, from 6 to 9 inches long, and the spoon-like extremities vary in size, shape, and depth.

Weiss's bullet scoop.—In this extractor the scoop is fixed, and forms the termination of the main stem of the instrument. The most noticeable part of the contrivance consists in a plan for deepening the scoop at pleasure by means of a supplementary spring. The stem is made of German silver, is flat, and becomes gradually narrower from the handle to the scoop. At the back of it is a steel slide, worked by a thumb-piece. On pressing the thumb-piece, the end of the steel slide is caused to project in a curved direction beyond the scoop, the concavity of which it proportionably increases.

It does not often happen in practice that scoops can be passed behind bullets in the manner here contemplated. Difficulties are constantly experienced in disentangling the bullets from the tissues among which they are imbedded, especially when they have been accidentally battered or altered in shape. The additional assistance of a finger in the wound is then rendered necessary. One of the arms of the midwifery forceps can be used as a scoop, and may occasionally be so employed with success when the wound admits the insertion of a finger in addition. The bullet can then be

loosened from its situation, and being pressed by the end of the finger against the blade of the forceps, can be held securely while being drawn away from the wound.

Fig. 35.



Tufnell's Bullet Scoop.

Tufnell's bullet scoop.—In this instance the scoop, which is circular in form, is hinged to a slender steel rod which passes through the hollow stem of the instrument, and is connected with a small spring thumb-piece and sliding bar near the handle. When the sliding bar is drawn backwards, the scoop is maintained in the same line as the stem of the instrument: when the bar is pushed fully forwards, the action of the connected rod causes the scoop to be placed at right angles with the stem. If the scoop be carried fairly to one side of a lodged bullet, and then caused to assume the rectangular position, it will necessarily displace the projectile and render its extraction easy. The difficulty, however, in the use of the instrument seems to be the liability that exists of the scoop dragging forward some of the organised tissues which may accidentally be brought in front of it at the time it is made to turn on the stem, or, subsequently, when it is being drawn out of the track of the wound. The position of the scoop, at right angles to the stem of the instrument, is obviously less favourable for travelling along the track made by the bullet than the oval and smooth blades of a forceps.

The want felt of some means of fixing a bullet in position after it has been got in front of a scoop led to the invention of the instrument next described. Until recently it has been one of the instruments included in the surgeon's 'capital case of instruments.'

Coxeter's bullet extractor.—The instrument known under this name in England consists of a cannula between 6 and 7 inches long, terminating in a slightly curved

scoop, the concavity of which near its edge is fitted with two small and sharp spikes. Through the cannula a steel rod passes freely. It can be drawn into the cannula or pushed downwards toward the scoop by means of a suitable handle. The end of the rod terminates in four points. If a bullet be caught within the scoop, the central rod or pin can be pressed down upon it so as to maintain it fixed in its position. The instrument can be readily used as a sound. No distension of the track through which a projectile has passed is caused while it is in use either as an explorer or extractor.

Fig. 36.

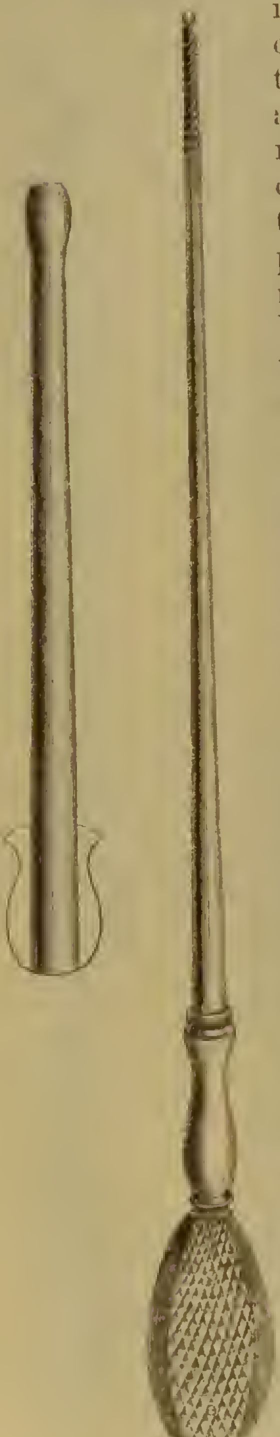
Coxeter's Bullet Extractor.

Salt's folding bullet scoop.—This is the same instrument as Coxeter's extractor, but is jointed in the middle so that it can be folded up into half its length. The cannula is divided into two parts, which are screwed together when it is required to be fixed. The central rod is also separated into two parts at the middle, and these are connected by a half-rule hinge, so that they can be laid side by side. It enables the instrument, which is ten inches long when fixed in position for use, to be reduced to five inches and carried in a pocket case. At the same time none of the parts are completely separable.

(*c*.) **Bullet extractors of the screw class.** Screw extractors are instruments which appear to be more frequently employed by Continental than British surgeons. An instrument of this class is contained among the authorised military surgeon's instruments in the French service, and is known under the name of the 'Tire-fond.' The patterns in the collection of the Army Medical School are of different lengths, from 12 to 7 inches long. Each consists of a slender steel rod, having a convenient handle for grasping at one end, and at the other a screw composed of a double thread. The portion round which the screw winds is conoidal in form, the base being continuous and corresponding in size with the shaft and thence gradually tapering towards the point of the instrument. By means of the double thread, the distance between the threads of the screw is diminished; and, from this circumstance, in addition to the length of the lever or handle, the mechanical power of

the instrument as regards its quality of penetration is greatly increased. The instrument is provided with a cannula, shorter by an inch or so than its own length. This cannula is expanded at the upper end for convenience of being held by the tips of the fingers while the handle is held in the palm of the hand, and is furnished with a rounded and smooth margin at the extremity. The purpose of the cannula is to act as a sheath, and thus to protect the sides of the wound from injury by the points or spirals of the screw while the instrument is being inserted. On the foreign body being reached by the rounded end of the cannula, this is drawn upwards toward the handle, when the screw is left exposed ready to bore its way into the body opposed to it.

Fig. 87.



Tire-fond Bullet Extractor.

It is obvious that such an instrument can only be usefully employed on condition that the foreign body is soft enough to admit of being penetrated by the screw, and that the parts behind it offer sufficient resistance to the pressure exerted upon them, so that it may remain stable during the manipulation for effecting its penetration. The screw could not be employed with propriety in a case of lodgement of a foreign body among soft tissues, for its pressure would simply have the effect of forcing the lodged substance before it into some deeper position. Extractors of the screw kind can therefore hardly be useful in any cases excepting those in which leaden bullets are lodged and firmly impacted in bones.

The sharp-pointed forceps, before described, will probably be found to be a more useful instrument in either of the cases just mentioned than the tire-fond screw. If the bullet be firmly impacted, the sharp-pointed forceps will readily get so tight a grip of it that, however firm the impaction may be, little difficulty will be met with in releasing it from its situation and extracting it. If it be placed in the yielding spongy texture of a bone, where the screw could scarcely be used without the likelihood of inflicting additional injury, the pointed forceps can be employed without any such risk; and yet as secure a grasp of the bullet be obtained as could be had by a tire-fond having been firmly screwed into its

substance. The absence of the tire-fond screw from the articles of British field surgical equipment cannot be regarded as a matter of much regret, although, in a few exceptional cases, when a sharp-pointed forceps has happened not to be available, it has been employed with useful results.

(*d.*) **Bullet extractors of the composite class.**—Instruments have been devised with a view to supporting the foreign body to be extracted, and thus protecting the surrounding tissues from the effects of undue pressure, at the time that the screw, last described, is in the act of being employed to effect a penetration into its substance; in other words, for adapting the use of screw-extractors to the removal of bullets lodged among the soft tissues of the body. The following is one of these instruments.

Tuson's bullet extractor.—This extractor, the invention of Dr. Tuson, of H.M.'s Indian Army, resembles Ruspini's and Goodchild's extractors in being a tripartite expanding screw forceps, but differs from them in the purpose to which the central steel rod is applied. The rod is armed with a two-threaded screw at its extremity. It is capable of being moved backwards and forwards within the expanded scoop, and is designed for fixing the bullet more securely when caught within the three blades of the forceps. The instrument is very ingeniously designed and well constructed. The three-bladed forceps does not appear, however, to have the same grasping power as the simpler two-bladed forceps, while the tissues are more distended in its use. The three blades, when expanded to their ordinary limits, present a circumference of three inches, and can be expanded to give a circumference of nearly five inches. The distension might be injurious in the hands of an unskilful operator.

Percy's tribulcon.—A compound instrument, which for many years had a great reputation, was contrived by Baron Percy, who gave to it the name of the triple tire-balle or tribulcon.[33] In this instrument Percy combined a forceps, a curette or scoop, and a tire-fond screw. The two arms of the forceps were connected by means of a small spring in one branch, and a revolving catch or bolt in the other—the purpose being similar to that of the joint in the midwifery-hinged forceps—so that they could be separated or locked together at pleasure. A ring formed the handle of one branch of the forceps, the scoop formed the other. The upper half of the stem of that branch of the forceps which was furnished with the bolt was hollow, and into this the tire-fond was received, and fixed by two or three screwing turns. The ring end of the tire-fond when it was screwed home formed one of the handles of the forceps. In using this instrument as a forceps the construction enabled each branch to be inserted separately. The scoop was made of the same shape as a scoop then generally used in lithotomy. The tire-fond was without a cannula, but Percy maintained that a cannula was of no value in the use of this part of the instrument.

Dr. Mouij's tire-balle.—This is an ingenious but complex instrument, admitting of being turned to various purposes in the exploration of wounds and the extraction of foreign bodies. The inventor has had in view the construction of an instrument suitable for being carried in a surgeon's pocket-case of instruments, and has therefore made it as light in weight and as portable as practicable. It comprises a forceps, a screw or tire-fond, and a Nélaton probe. These appliances can be used either for direct or tortuous wounds: in the latter cases a flexible portion is added to the instrument. The inventor claims for it the following advantages:—1. The blades of the forceps are so constructed and toothed as to be able to grasp at any part of their outline, so that it matters not what the shape or the position of a bullet in a wound is. 2. It is not necessary that the blades should grasp the whole of the bullet. 3. A sufficient portion of the lead can be detached, if desired, to recognise the presence of metal without a magnifying glass or chemical test; and 4. With the extractor arranged for tortuous tubes, foreign bodies can be taken out of the œsophagus with facility.[34]

Barclay's case of bullet-extracting instruments.—The difficulty of extraction is sometimes greatly increased when the bullet which is to be removed has been lodged long enough to have become encysted. The cyst wall, or some parts of it, will sometimes be so strongly adherent to the bullet, that a separation can only be effected by forcibly tearing or cutting them asunder. The occasional difficulty which results from this intimate attachment of cysts is one which surgeons must be prepared to meet in operating for the extraction of bullets after prolonged periods of lodgement. The late Surgeon-General Dr. Barclay, owing to repeated experience of this particular complication, caused to be made for him a pocket-case of instruments specially suited for dividing the fibro-cellular entanglements of lodged bullets when sacculated, and thus facilitating their extraction. Dr. Barclay presented a case of these instruments to the Museum of Military Surgery at Netley.

The case contains: 1st. Three pairs of spring forceps. Each forceps is armed at its grasping ends with a set of teeth which lock into each other when the ends are in contact. The ends differ in width, and the teeth vary in number and direction in each forceps. All these are devised for the purpose of *biting into* a leaden bullet so as to prevent it slipping away from the hold of the instrument. 2nd. A duplex scoop 6 inches long. The two scooped extremities vary in width. This instrument is intended for withdrawing bullets with the aid of a finger. 3rd. A bistoury with the blade much curved. It has a sharp edge on the convex side, and is devised for dividing either cellular envelopes, or bands of adhesion, when they impede the extraction of bullets.

CHAPTER VI.

CONSTITUTIONAL TREATMENT OF SOLDIERS SUFFERING FROM GUNSHOT INJURIES IN TIME OF WAR.

Exhaustion among wounded soldiers in the field.—Having considered the local treatment in the field and field-hospitals of patients suffering from gunshot wounds, it becomes necessary to make some remarks upon the general or constitutional treatment which should accompany it. It is hardly too much to say that next to arresting conditions which threaten the immediate extinction of life, such as loss of blood from wounded vessels and extreme shock, there is nothing more essential for the safety of the lives of men who are badly wounded, than the early administration, occasionally of a moderate stimulant, always of proper nutrient support. This support is as necessary, in the early condition in which wounded men are usually found, as a preventive against mischief, as its subsequent administration is for maintaining a healthy process of repair in the wounds from which they are suffering. It is true that remarkable instances of recovery occur occasionally under circumstances of extreme neglect, of exposure, and enforced abstinence, extending even over several days and nights. It may be admitted that, rather than crowd wounded men in unsuitable close rooms, it is better to subject them to all sorts of inclemency of weather in the open air; but it is certain that a very large number of wounded men will sink under such circumstances, unable to resist the prostration due to the want of means of counteracting the depressed state of system, physical and moral, into which they are thrown by their injuries, and the neglect and exposure combined. In many, no rallying, or only very partial reaction from the condition of collapse, takes place; the heart's action flags more and more, and eventually stops altogether. It is notorious that soldiers, although appearing to present a high standard of physical strength in campaigning, are often only stimulated to this appearance by the excitement of the circumstances in which they are placed. As soon as this stimulus is taken away, as happens when a soldier is placed *hors de combat*; when he is suddenly removed from a condition of extreme bodily activity in the discharge of his duties, of life spent chiefly in the open air, and of mental diversion owing to the constantly recurring changes of scene which accompany them, and, instead, is reduced to a state of enforced quietude in an ambulance by an overpowering injury, probably oppressed by pain and anxiety; then, the fatigue, the broken rest, irregularity of meals, and the disturbance of his ordinary habits of life, which he has previously

undergone, soon manifest their effects by producing a state of constitutional exhaustion in the patient.

This exhaustion happens even under favourable hygienic circumstances in campaigning; it is greatly more marked when the circumstances in which the soldier has been placed have been unfavourable to bodily vigour and health. When the campaign has been carried on in a marshy or otherwise unhealthy country; when the men have been camped in tents, overcrowded or too closely pitched together; when the troops have been exposed to some deleterious epidemic influence, or subjected to wet and much vicissitude of weather; if they have been shut up in a besieged town or fortress; and especially if they have been badly nourished; the depression that follows disablement from injury becomes proportionably all the more conspicuous.

In all campaigns in which the rations have been coarse, deficient in quantity, or defective in nutritious qualities, without sufficient variation and ill-cooked, a weak and impoverished condition of constitution, closely allied to that of scurvy, has been from this cause alone gradually engendered among the troops. Hence, when wounds have occurred, many of them which might have taken on a healthy action under other circumstances, have only progressed from bad to worse until, in a large proportion of instances, a fatal termination has closed the scene. Erysipelas, hospital gangrene, pyæmia, bowel diseases, and other grave local and general complications, find a ready soil and ready means of development, in the scorbutic conditions of constitution induced by the continued use of food inadequate in nutritive value to meet the physical wear and tear to which troops are habitually subjected in campaigning, especially when this defective nutrition has been joined with some of the other unhygienic conditions which have been already mentioned. The influence of the bad diet and other unsanitary conditions to which the British troops were subjected in Bulgaria,[35] contributed in a great measure to the untoward results that attended many of the wounds received in the first great battle—that on the Alma—after the landing in the Crimea; while it favoured that scorbutic taint, which gradually became so fully developed under the privations of the first winter passed in the Crimea itself, and which so strongly manifested its effects in the unhealthy action taken by the wounds (fortunately comparatively few in number) received during that period of the war. In all prolonged sieges, down to the late siege of Paris, especially at the latter periods of them, the difficulty of treating wounds with success among the besieged has been greatly enhanced by the deteriorating effects of the want, and unhygienic conditions, to which the patients have been previously subjected. Depression of bodily energy from whatever cause it may have arisen, unless it can be removed by judicious care and treatment, must always form a grave feature in

the condition of a wounded man, both as regards the repair of the local injury, and the patient's prospects of ultimate recovery. Of course, if these conditions have in addition been complicated with any considerable loss of blood at the time of the injury; or, if cold and damp are present to assist in enfeebling the general circulation and in arresting the flow of blood through the superficial capillaries; the hazardous character of this exhaustion becomes aggravated in a greatly increased degree.

Necessity for early administration of nutrient support.—From what has been above said, it follows that in all severe gunshot wounds received during the course of a campaign, but especially under circumstances of previous constitutional deterioration, the administration, as early as practicable, of warm nourishment in a suitable form is a point of essential importance. The first object is to prevent the condition of exhaustion sinking so low as to make it a matter of risk and uncertainty whether the wounded man will be able to mount from it again: the second object is to counteract the consequences of this depressed condition, to increase the vigour of the patient's constitution, and prepare it for future trials. The restorative powers must be rallied and maintained so that they may have a fair chance of being able to meet the demands which will be made upon them in combating the depressing influences of hospital confinement, and, at the same time, in repairing the injury which has been inflicted. To accomplish the first purpose, it is often better to postpone the primary examination and dressings at the ambulance, or hospital, until some regular nourishment has been given, than to postpone the nourishment till the dressing has been done. This will especially be the case if much time has elapsed between the receipt of the wound and the removal into hospital; if the patient is cold from having been lying a long time on the ground where he has fallen, from exposure at night, or if there be so many wounded that a good deal of delay must occur before all can be surgically attended to. The free use of good nourishment before and after their injuries was one of the advantages which the British wounded enjoyed in the Crimea after the first winter had passed, and was probably one important source of the different results of the treatment in the English and French hospitals during the latter period of the campaign; and almost all the surgeons who were engaged in practice during the great civil war in the United States refer to the very liberal and varied dietary given to the wounded in the field and general hospitals, as having been one of the chief causes of the great success which attended their treatment.

The successive constitutional conditions of wounded patients.—On looking generally at the course through which a patient with an ordinary gunshot wound has to pass, three constitutional conditions are usually conspicuously marked. The first is a condition

of depression, more or less profound and prolonged, according to the specific nature of the wound, its concomitant circumstances, and the state of the patient's constitution; the second, one of simple reaction, though varying in degree; the third, a condition of constitutional irritability, more or less marked, which continues during the suppurative and reparative stages of the local injury.

Constitutional treatment during the first stage.—The necessity for restoratives in the shape of moderate doses of stimulants, warm refreshing beverages, and proper nutriments, in the first condition has been sufficiently remarked upon. All that can usually be done to meet this need on the field of battle itself, even though the ground may be clear of fighting, is to give a little spirit, or aromatic ammonia and water, to an exhausted patient. This will enable him to bear the transportation to the first dressing station better. On arrival at it, some of the medical comforts provided in the bearer-company's wagons or field panniers ought to be administered as speedily as circumstances allow. These consist of such articles as cocoa-milk, tea, arrowroot, and, best of all, the extract of meat for forming beef tea. If the field-hospitals be established in houses or other buildings where the opportunity is afforded for making such arrangements, or if the patients can be carried at once from the field into hospitals of a more permanent character, as may happen in besieged places, then, whenever necessary, in addition to warm stimulants, or warm broth, warmth and reaction should be encouraged by getting the patients speedily into bed, applying heat to the extremities, and adopting any other means available for accomplishing the purpose.

An excess of alcoholic stimulation must be particularly guarded against in the first stage of depression, as, indeed, it should be throughout the whole course of treatment. The exhibition of an undue quantity of alcoholic beverage ceases to be a simple restorative, it creates an over-excitement which must lead to a proportionate depression of energy afterwards. The amount of stimulus that is confined to simply restoring the disturbed balance of power for the time will be serviceable; all stimulus beyond what will contribute to this result will be hurtful. There is little probability of nutrient restoratives being given in excess at the first period of treatment; if they are exhibited beyond the powers of the patient to assimilate them, either he will refuse them when offered, or, if he swallow them, the stomach will reject them. With alcoholic stimulants the case is different; the habits of soldiers, and the nature of alcoholic stimulants, cause an excessive quantity of such stimulants to be very readily taken. There is an unfortunate custom, in some armies, of issuing a spirit ration to the men shortly before going into action. It is a most pernicious practice under the usual circumstances of warfare, for although it may keep soldiers in a state of excitement during a limited time, if the

engagement be prolonged, it will not fail to heat them and make them more exhausted than they would have been if they had not taken it. To the soldiers who fall wounded it is especially hurtful. It intensifies thirst, leads to increased depression, and often prepares the way for very serious complications in cases where the wounds inflicted are of a grave character. The treatment of wounded men who have been drinking spirituous drinks immediately before the receipt of their wounds requires special caution, and is always a matter of difficulty.

Constitutional treatment during the second stage.—During the second stage of reaction the power of assimilating food, as well as the desire for it, will in a great measure be wanting; so that, still, only nutrients in a very diluted and easily assimilable form are admissible. Two things usually force themselves on the attention in this stage: the local reaction at the seat of injury, and the systemic reaction. These are, in part, independent of each other, in part dependent on each other. If the wound be one not involving organs of first importance, and the patient be in a sound and vigorous condition, the reaction, both local and general, under favourable hospital circumstances, will be so moderate as to cause no anxiety to a surgeon. If a like wound occur in a patient debilitated by long-continued fatigue and exhaustion, by exposure to unhygienic conditions, the reaction may be very different in degree and in its nature. Other causes, the extent of the injury, its complications, a plethoric condition of the patient, nervous excitement, may induce excessive reaction, and the question of the proper treatment to be pursued is one requiring careful consideration. In former days bleeding was freely resorted to in such cases. Venesection was supposed to be absolutely necessary to restrain the vascular excitement within moderate limits. Depletion in various other forms was resorted to. Nauseants, purgatives, restriction in diet and drinks, were called into requisition to aid the antiphlogistic treatment. Few modern surgeons believe such a drain on the circulation, or such depressing medicines and regimen, to be beneficial, much less necessary as a general rule. The prevailing conviction, now, is that although under their influence excess of inflammatory action may be reduced, the vital power of the patient is also reduced; so that he is left deprived of the means necessary for a favourable restoration of the structures which have been mutilated by the shot, or for the healing process in case amputation has to be resorted to. He loses at the same time the strength necessary for resisting the effects of loss of exercise and confinement, and of the morbific agents to which, more or less, he will probably be subjected during the prolonged period of hospital treatment. At the best, after such depletory treatment, the rate of the patient's convalescence is slow, and he is certainly exposed during its progress to far greater and more numerous risks than

another patient who has not been so reduced. It is on this reasoning that modern surgeons avoid abstraction of blood in all but exceptional cases, and employ only the mildest forms of remedial agents in their attempts to keep the vascular excitement during the condition of reaction within due limits. Rest, as complete as possible, by the aid, if necessary, of chloral or morphine, the simpler kinds of diaphoretics and diuretics, acidulated drinks, are joined with the usual applications at the seat of injury, in order to calm the inflammatory excitement, local and general, prevailing at this stage.

If there be much pain about the wound, opium in some of its forms may now be freely given with advantage. The value of this remedy consists not merely in the reduction of the local pain, and in soothing spasm, but principally in its influence over the mental irritation and constitutional disturbance which result from them. It procures that ease and repose which are essential for the restoration of the balance between the variously disturbed functions of the patient's frame. During the last few years the hypodermic administration of morphine has come into general use; and, when due precautions are taken as to the quantity employed, as to the state of the patient, that he is free from severe shock or collapse, there can be no doubt that it possesses many advantages over all other modes of administering opium in gunshot wounds accompanied with pain, and that, under the conditions named, it may be used from the first with much advantage. Relief from pain is afforded by it with much greater certainty, and with much more speed, than when any form of the drug is given by the mouth. The stomach and digestive organs are often in such a condition, in patients suffering from the irritation of painful gunshot wounds, that considerable quantities of an opiate may be swallowed without much apparent effect; it remains inert, or nearly so, for the time, while a very minute quantity injected under the skin suffices in a few minutes to induce the desired result. Not very long before the Franco-German war of 1870 a new field surgical knapsack was introduced into the army medical service of the North German Confederation, and one of the articles inserted in each knapsack was a hypodermic syringe and a supply of morphine solution. As mentioned in the chapter on hospital equipment, a similar provision is now made in the field panniers and pharmacy wagons of the British service. The hypodermic use of morphine was largely resorted to by the volunteer surgeons sent to assist in tending the wounded in France and Germany by the English National Aid Society, and all the reports say that its use was attended with the most marked beneficial results in relieving pain, and lessening constitutional disturbance.

Chloral was also extensively used as a calmative remedy in gunshot wounds during the same war. Baron Langenbeck praised its employment highly, especially for allaying spasm after amputa-

tions and other surgical operations necessitated by gunshot wounds. He considered it superior to opium for this purpose. The combination of the bimeconate of morphia with the chloral has been stated to give increased efficiency to the drug. Fifteen grains of the hydrate of chloral with a third of a grain of the bimeconate have been recommended for forming a soothing draught to allay local traumatic irritation and to induce sleep in all painful gunshot injuries.

The mention of sedatives leads me to say a few words on the use of tobacco. Although smoking is only permitted under certain restrictions, and in exceptional cases, in the wards of English permanent military hospitals, it is rarely objected to in field-hospitals. The only sound objection to the consumption of tobacco is the danger of setting light to bedding, tents, &c.; for there are few soldiers among the limited few who do not smoke to whom the smell of tobacco is disagreeable, while to the majority it is not simply a luxury, but from long habit, a daily necessary. Cleanliness, notwithstanding its use, can easily be provided for. It is questionable whether there is not more danger from fire when tobacco-smoking is not allowed, than when it is; for under the former arrangement the men, on the approach of an officer, frequently conceal their lighted pipes under the clothing, or they smoke at hours when they are not likely to be visited, and as this will be chiefly at night, it will be at a time when they are not unlikely to fall asleep and drop their lighted pipes unconsciously on the bedding. It is not, however, because smoking tobacco is a habit with soldiers, which becomes a source of much discomfort if it cannot be gratified, that its use should be allowed in field-hospitals, but on account of its sedative and other medicinal qualities. No one can doubt its soothing effect on men suffering from the pain of wounds, or that it allays nervous excitement, and produces a state of calm which helps to secure the rest which is so beneficial to them in every way. The contentment it affords to the patient helps the surgeon in his work, and enables a man to submit cheerfully to many deprivations unavoidable from the circumstances of his position, the absence of which, without it, would fret and worry him. Perhaps none of the presents from Aid Societies have been so much appreciated in hospitals as the presents of cigars and tobacco in various forms; for they have usually arrived at times when it has been difficult for the patients to obtain supplies from other sources. It is not among the hospital supplies; though, considering its utility, it is doubtful whether it might not be made one with advantage for issue under special circumstances.

Constitutional treatment during the third stage.— When the stage of reaction has subsided, when the tumefaction and inflammation about the seat of injury are declining, sloughs in progress of

separation, suppuration fully established, and when the desire for food is improving, it is essential that no judicious means of complying with this appetite, and so supporting the strength of the patient, should be neglected. Decline towards a scorbutic taint should be keenly guarded against. No medicines are necessary, unless occasionally required for assisting the excretory organs, which are apt to become torpid in the performance of their functions from cessation of the active movements to which the body has been accustomed when in a state of health. What the patient chiefly requires under such circumstances is good and sufficiently varied food, as fresh and pure an atmosphere and as full a supply of it as can be obtained, and such cheerful diversion of his thoughts as the position in which he is placed admits of being afforded. Should hygienic rules have been practically carried out during the campaign, so that the soldier was in a good state of general health at the time he was wounded,[36] if the treatment just named can be provided for him while he remains under hospital care, and if no local complications exist at the time of injury, the wound will progress towards recovery with regularity and without any trouble, while the constitution of the patient will in no material respect be impaired. Where special states of constitution are met with, they must of course be specially dealt with, but the general principles on which the treatment is conducted ought always to remain the same as they have just been described. It is during the stage of suppuration, which is often very protracted owing to the nature of the injury, that the advantages of having rallied and fortified the wounded man by a supporting diet and regimen, will be particularly made manifest. When the vitality of a patient, already in all probability lowered by previously exhausting agencies, has been allowed to become further reduced by want of a properly supporting treatment, he becomes unable to resist a tendency to morbid degenerating processes when he is placed in favourable conditions for their development, he becomes unduly sensitive and irritable, and he readily falls a victim to suppurative fever, or to that great scourge of military hospitals, pyæmia, or he becomes the subject of visceral diseases, which though slower in progress, ultimately lead to the same fatal issue. There can be no doubt also that many of the cases of secondary hæmorrhage which occur in field-hospitals are attributable quite as much to lowered systemic vitality as to the local injury which has been done, whether by the original wound, or by subsequent surgical interference.

At the same time that the necessity for well-cooked, nutritious, and easily assimilated food is dwelt upon in the treatment of patients with gunshot wounds of a severe character, it is equally necessary for a surgeon to put the attendants on their guard against allowing an excess in quantity to be given to them. Cram-

ming a patient, who is unable to take exercise, in whom no waste of tissue takes place from exertion, will in many instances not simply be of no use, but will act as a positive source of detriment. Excess of food, almost equally with excess of stimulants, will irritate the constitution, increase the amount of suppuration, and act as a preventive of cure. The food, while nutritious in character, should be limited to the amount that can be properly assimilated. It is the digestible quality of the articles, and not their largeness of quantity, that is of importance. The diet, so far as the amount which is suitable is concerned, must be adapted to the circumstances of each particular case. In addition to the ordinary articles of diet, fresh or dried fruits, if they are procurable, should be freely given; in their absence, vegetable-acid beverages—lemonade, tamarind, or lime-juice drink, rendered palatable—or other articles of a similar nature,[67] should be substituted for them. It is not to be expected that such things will be found, under ordinary circumstances, among the regular supplies of field-hospital stores; but occasions will not unfrequently occur when they can be procured for use, at any rate in the general hospitals to which wounded men are removed from the field-hospitals for treatment, and these occasions should never be neglected. The necessity for the strictest cleanliness of hospital tents and wards with their precincts, of bedding and articles of apparel, of the clothing and persons of attendants, and the importance of regular and speedy removal of all soiled dressings and excreta, and of the constant purity of utensils and all hospital equipment, in order to maintain the atmosphere immediately about the wounds themselves in as pure a state as practicable, have been already adverted to when describing the local treatment. The preservation of a pure atmosphere is, however, of even greater importance as regards the constitutional health of the patients. A vitiated atmosphere, crowded with impurities, acts deleteriously enough on the wounds by its local effects, but far more does it act so on them by its toxic effects on the general constitutional state of patients. In proportion as constitutional health becomes impaired the healing process becomes less vigorous, takes place more slowly, and, in deep gunshot wounds, the tendency to diffusion of purulent secretions and the formation of distant abscesses followed by unhealthy sinuous tracks and openings, as well as to accidents of a still graver nature, becomes more and more marked. Unfortunately, although all the necessary manipulative details to ensure cleanliness which have just been referred to may be duly attended to, there are often great difficulties from other causes in maintaining a sufficiently pure atmosphere in field-hospitals. The concentration of large numbers of wounded, which is usually unavoidable for some days after a great battle, in the field and other hospitals; the employment of buildings as intermediate hospitals which are not at all suited to the purpose

owing to their construction, previous uses, or the condition of their environs; the want which frequently exists of means for separating the wounded from patients struck down by fevers and dysentery; these, and other such circumstances, entail special difficulties in the way of securing that purity of atmosphere which is essential for the favourable progress of patients labouring under sloughing and suppurating wounds. Special attention has been paid during recent years to the subject of distributing the sick and wounded in armies, as they accumulate, as widely as possible in comparatively small hospitals, instead of aggregating them in a few large hospitals; and the steps necessary to attaining this end are better understood now, than they were formerly.

When the plan of dispersing the wounded in small and widely separate hospitals cannot be carried into effect, and when, therefore, many wounded men have to be treated under the same roof, it must be borne in mind that the amount of fresh air to be supplied to the apartments in which they are placed ought always to be greater than need be given to patients affected with ordinary diseases. Perfect ventilation of the wards should be ensured, whenever practicable; so that not only the air which is deteriorated by the ordinary causes of respiration and transpiration, but also the emanations from the sloughing and suppurating surfaces, may be carried off as fast as they arise. To obtain this result there should be such arrangements, as regards the inlet and outlet openings, as will admit of about 3,000 cubic feet of air traversing the ward hourly for each patient contained in it. We know how constantly this very essential part of the treatment of wounded men is neglected in the temporary hospitals employed in time of war, or is rendered impracticable from the nature of the buildings converted to hospital purposes; and this fact alone explains the often repeated observation, that there may be a lower rate of mortality among wounded men treated in the open air, notwithstanding all the dangers which arise from exposure to rain and cold, than among those treated in buildings which appear to be all that is desirable on account of the protection and comfort they are capable of affording to the inmates.

The means of affording mental diversion to wounded soldiers in military hospitals in time of war, have been greatly extended of late years. The attainment of this improvement in their condition has been one of the results of the advance of civilisation. It has become understood that the exercise of the intellectual faculties, by means, and within limits, suited to the condition and circumstances of patients, is one ingredient in helping them towards recovery. The increased facilities of communication, locomotion, and transport, have assisted in bringing these means within their reach in sufficient variety. The spread of sympathy in regard to the concerns and necessities of those who most directly suffer from

the effects of war, has also effected much in this direction. But it is questionable whether, with all the improvements that have been made in this respect, there is any form of intellectual diversion which succeeds for long together in satisfying the mental wants of badly wounded men—who, for the most part, must remain for considerable periods of time in a convalescent and disabled condition—excepting complete removal from the theatre of warfare, when it is away from their native country, to their own homes, where they can renew old ideas and old associations of feeling among relatives and friends. To return to their own country and homes, is usually the one longing wish of wounded men, as soon as they have recovered so far as to feel themselves able to undertake the fatigue of the removal.

It is evident from the general tenor of the preceding remarks, that the most important part of the general or constitutional treatment of wounded men consists in maintaining them under favourable hygienic conditions. Implicit obedience to hygienic rules is essential, not merely for warding off fresh evils, but for keeping the constitutions of patients in such a state as will admit of their wounds pursuing a healthy course of action. If a certain number of wounds from their own nature may be expected, under favourable hygienic circumstances—with a pure atmosphere, pure water, appropriate diet, and due attention to personal and surrounding cleanliness—to be attended with a given amount of disablement and mortality, that amount will be vastly increased from constitutional deterioration under hygienic conditions of an opposite kind, whatever may be the degree of surgical skill and nursing bestowed on the patients. The enforcement of hygienic requisites ought, it may therefore be said, to be the first and last subjects of consideration on the part of the presiding surgeon, so far as the constitutional treatment of his wounded patients is concerned.

CHAPTER VII.

TREATMENT OF SECONDARY COMPLICATIONS OF GUNSHOT INJURIES.

General remarks.—The treatment of gunshot injuries which has been described in the foregoing pages, may be regarded as the preventive treatment of most of the secondary complications to which gunshot injuries are liable. If the local and general treatment laid down be followed out, and the patients be placed under suitable hygienic conditions, no secondary complications will arise in the majority of cases to cause the surgeon anxiety. They will occur in exceptional cases where all the requisite steps have been taken to prevent their occurrence; but, under such circumstances, they will

very rarely present a severe type, or spread so as to assume an epidemic character. On the other hand, they will very generally arise in some form or other, where circumstances have occurred to prevent proper hygienic and surgical treatment of the patients being systematically practised; and, under such circumstances, may readily become generally prevalent.

It becomes necessary, therefore, to take into consideration the special treatment to be adopted when either one or other of the complications, elsewhere described, takes place. The treatment will be noticed in the order in which the complications themselves were described.

Treatment of inordinate inflammation in gunshot injuries.—It is a matter of first importance, when preparing to subdue excessive inflammatory action after gunshot injuries, to form a right opinion respecting the cause of the undue excitement, and to consider well the state of constitution of the patient in whom it occurs. The treatment which might judiciously be adopted for controlling inordinate inflammation of a sthenic character, would manifestly be calculated to do harm if it were of an opposite type. The depletory measures which would be advantageous in excessive inflammation of a gunshot wound inflicted on a man of vigorous frame, would not be borne with impunity by another with reduced constitutional power; but would probably only serve to give the existing inflammatory excitement further extension, and to make it more difficult of restraint within due bounds.

If the excessive degree of inflammation can be traced to mechanical causes, such as violence to the wounded parts from bad transport, or accidental additional injury from lodgement of irritating substances, rest and antiphlogistic remedies are plainly indicated as a first measure to be practised. Under all circumstances, so long as the inflammatory excitement lasts, rest is a most essential part of the treatment. This includes general rest of the limb or part of the body in which the injury is situated, and rest of the particular anatomical structures involved in it. The first, or general rest, will be best ensured by a judicious and easy position, and by suitable supports, so that all muscular strain is avoided. In using supports undue pressure must be guarded against, so that no irritation may be excited from this cause, and neither the sanguineous nor the nervous circulation be in any degree impeded. A judicious selection of supports as to their kind, and a judicious arrangement of them, become important matters to be considered according to the nature and site of each particular injury, so that the special objects aimed at in their employment may be attained without the drawbacks just mentioned. Rest of the particular anatomical structures involved in the wound, can be best ensured by interfering with them as little as possible after the general repose of the part of the body in which the wound is situated has

been secured. Although there may be reason for suspecting that lodged foreign bodies have acted as the exciting cause of the inordinate inflammation, no search for them should be made, nor any efforts exerted to extract them while the inflammatory action is high, unless they are visibly within reach. Such operative interference would in all cases add fuel to the fire, and, in occasional instances, may provoke serious aggravation of the complication present. Irrespective of the great pain which such proceedings would cause in the inflamed parts, nervous irritation will sometimes be set up which may easily pass beyond the limits of control. The exploration of gunshot wounds to search for foreign bodies in them, when the parts concerned are in a high state of inflammation, is a most injudicious undertaking and merits strong disapprobation. Efforts should be made to soothe the inflamed parts as much as possible, and to reduce the inflammatory excitement within simple limits, and then, after the accomplishment of these objects, the exploration may be proceeded with, and foreign bodies, if detected, be removed. To reduce the inflammation, evaporating applications may be resorted to, or the local abstraction of blood by leeches or suitable incisions, at the same time that internal remedies calculated to reduce the force of the heart's action are administered. As a general rule, it is not desirable to apply too low a degree of cold to wounds in which inflammation has arisen in an inordinate degree. The application of ice is, therefore, in such cases not an advisable proceeding; and, in applying moistened lint, three or four layers of the material, placed one above the other, form on the whole a more soothing and safer dressing than a single layer, by which a greater degree of cold is attained through more rapid evaporation. It is rarely advisable to abstract much blood, even locally, from the patient: his strength rather requires to be economised for resisting the subsequent ordeal of depression, which he will have to pass through when the stage of inflammatory excitement has subsided. But in cases in which considerable swelling and local congestion have taken place, in which the inflammation is accompanied with much pain and tension, and is causing constitutional disturbance, the employment of a few free incisions to relieve the tension, and, aided by subsequent fomentation, to cause a sufficient flow of blood, or the application of a few leeches, may cause speedy relief and be productive of much benefit. Some surgeons still advocate the application of large linseed-meal poultices, so as to envelop the wound and the whole of the inflamed parts adjoining it; but, owing to their weight, soddening action, and other objectionable qualities, elsewhere alluded to, they cannot be recommended for the purpose any more than they can be as applications to gunshot wounds in their early stages. The medicines employed should be calculated to excite moderate diaphoresis, to maintain regularity of the excretions, but should neither derange the stomach nor tend to debilitate the

patient. Saline medicines, the mineral acids, and the milder diaphoretics, attention being given at the same time to the diet and drinks so that these may be appropriate in kind and amount to the degree of pyrexial disturbance present, are generally all that is required as regards constitutional remedies; while they will far less tend to interfere with a healthy process of repair in the wounded structures, than remedies of a more violent and depressing nature.

The local application of ice, when it can be obtained, is advocated by some surgeons for the reduction of excessive inflammation in gunshot wounds. In certain wounds, such as penetrating wounds of articulations in which conservative practice is followed, the careful use of ice for this purpose is advantageous; but in most gunshot wounds of a severe character the vitality of the tissues has been reduced to such an extent by the injury to which they have been already subjected that the reduction of temperature and vascular action by ice becomes a hazardous proceeding. It is all the more dangerous when the patients are generally reduced in constitutional strength. It is only in exceptional circumstances, as when the wounded are treated in towns or cities, that ice can be obtained for such purposes; and, even when available, it can, for the most part, be more beneficially employed in cooling the water or other beverages given to the patients.

The inflammatory action may subside, and the parts involved in it resume the condition in which they were before the occurrence of the complication; or it may terminate in gangrene; or in copious suppuration, the matter being discharged freely from the wound, or diffused among the tissues which had been subjected to the inflammatory excitement, or accumulated in isolated purulent collections. The treatment to be followed under each of the conditions named is described elsewhere.

Treatment of gangrene in gunshot injuries.—The treatment of gangrene may most conveniently be noticed under the two forms which were mentioned in the remarks on this affection, viz., Local and Distant Gangrene.

Local gangrene.—The treatment of local gangrene, when it is limited to the parts which have been deprived of vitality by the direct action of a projectile, is of the simplest character and has been previously described. It is little more than protective while nature is engaged in the process of removal of the gangrenous tissues preliminary to that of repair.

If, however, the gangrene be not thus limited, but shows a disposition to spread, and is accompanied with much heat and pain, or, without these active symptoms, is accompanied with marked constitutional depression, more special treatment becomes necessary. As a general rule, constitutional remedies will have more influence in arresting the extension of the gangrene than

topical applications. The principle on which the general treatment is conducted must be that of increasing the bodily strength of the patient. Any nutrient support that can be assimilated should be freely given. Stimulants in moderate quantities are often of essential benefit in counteracting the exhausting effects of the diseased condition, and in raising the flagging powers of the patient so as to enable him to digest the food he is able to take without difficulty. Nutriment should be given in the most concentrated, but at the same time in the most assimilable forms. Small quantities frequently repeated are better for the purpose than larger amounts at prolonged intervals. The important point is to keep up the strength of the patient; for, in doing so, we shall best enable the textures adjoining the gangrenous parts to resist invasion, and we shall lessen the nervous irritability of the patient. It may be taken as a rule that the more the gangrenous action shows a disposition to spread, the stronger is the evidence of exhaustion in the constitutional vigour of the patient: and, consequently, of the need of a supporting and strengthening line of treatment on the part of the surgeon.

If the gangrene be accompanied with much pain and disturbance of sleep, opium in some of its forms will be most beneficial. It may not only be administered as a medicine internally, but may be applied locally, either by being dusted in the form of powder about the wound, or by being employed as a lotion. Quinine, and the mineral acids, iron, and other tonics, are often beneficial. Such sources of general irritation as intestinal accumulation must be carefully guarded against.

The fœtor may be corrected by any of the usual antiseptic lotions. Among these the carbolic acid is now the one which is most generally employed. Terebene may be found to be equally effective, and less objectionable as to its own odour. Charcoal poultices may be used for the same purpose.

Distant gangrene.—When gangrene threatens to commence at the termination of an extremity in consequence of a wound at its upper part having been attended with some lesion of the main vessels, so that the circulation through the limb has become more or less impeded, treatment should be adopted in the first instance with a view to prevent the threatened mischief. Efforts should be made to ensure the maintenance of a normal and equable temperature by enveloping the limb in cotton wool, and by the application of artificial warmth, at the same time that the posture and kind of support most suitable for rendering the circulation easy through it are properly attended to.

When, however, gangrene declares itself decidedly, notwithstanding the preventive measures which have been adopted, and advances steadily up the limb, serious questions arise respecting the proper treatment to be adopted—whether amputation must be

resorted to, what should be its site if it be determined upon, or whether the operation may be delayed until the advance ceases, and a line of demarcation between the living and dead tissues is established. These are special questions which can be best discussed when injuries of the blood-vessels are treated upon, and the subject of amputation in general is considered.

Treatment of secondary hæmorrhage after gunshot injuries.—The many different circumstances, which have been elsewhere enumerated as the occasional causes of this complication, sufficiently point to the different principles on which its treatment must be based in different cases.

The treatment of the hæmorrhage which occurs during the early period succeeding a wound, and is due either to local disturbance or fresh injury of a wounded vessel, or to increased arterial excitement, differs in no respect from the treatment of primary hæmorrhage. A knowledge of the sources of local injury sufficiently indicates what would have acted as means of prevention; but, when the recurrence of bleeding has been thus accidentally set up, it must be controlled and arrested in the same way as if it were a first occurrence. Hæmorrhage produced by the effects of reaction on the circulation, or by cardiac excitement, must also be treated on the same principles as the arrest of primary bleeding, according to the nature, size, and situation of the vessels involved. This treatment has already been considered when describing that of primary hæmorrhage.

Secondary hæmorrhage, the result of ulceration or sloughing of the vascular coats, gives rise to a necessity for considerations over and above those which have to be given to hæmorrhage occurring at earlier periods. The state of the vessel itself, as well as of the surrounding structures, will have now become changed from the effects of inflammation. Still the general rule is the same as in primary bleeding; viz., to place a ligature, or ligatures, at the part of the vessel from which the bleeding is taking place, instead of tying the vessel elsewhere at a distance from the wound. The same reasons hold good for this proceeding in secondary as in primary bleeding; viz., the greater assurance given to the surgeon that the right vessel is ligatured, and the security afforded against a return of the bleeding, especially from the distal opening, through the influx from collateral branches. The operation is rendered more difficult on account of the infiltrated condition, and altered aspect, of all the structures involved in the wound. Especial care has also to be taken not to apply the ligatures to the bleeding vessel too violently, on account of its diminished elasticity and power of resistance. The unhealthy and more yielding condition of its outer tunic—the result of the morbid action to which the vessel has been itself subjected, and probably in part also to the effect of the suppurating state of the tissues surrounding it—has

to be particularly taken into account in applying a ligature to it. The ligatures will probably have to be applied at a little distance from the bleeding aperture, in order to secure sufficiently sound and reliable parts of the vessel for their application. Some eminent surgeons have objected to placing ligatures at the bleeding part of the vessel in such cases, from a conviction that they would inevitably fail to accomplish their intended purpose owing to the vessels in their altered condition yielding under their pressure; but experience has proved that ligatures, if carefully applied, will retain their hold not only on vessels in suppurating wounds, but even in sloughing wounds; and, moreover, if the constitutional state and other circumstances be favourable, that they will lead to the obliteration of the tied vessel, as in other cases, and a permanent arrest of the bleeding. Efforts, therefore, should always be made, at any rate in the first instance, to secure the bleeding vessel in the wound itself, and to apply ligatures both above and below the opening whence the escape of blood is taking place, before resorting to other measures.

It can only be in rare and exceptional instances that the employment of styptics can be of permanent avail in such cases of secondary hæmorrhage; and, therefore, in all cases where the character of the hæmorrhage points to a vessel of considerable size as being the source of the flow, their employment had better be avoided. Their action on the tissues is to deaden to a certain extent their vitality, and they thus tend to place the parts in a condition favourable for the extension of the morbid action which has originated the existing mischief. The application of pressure, whether by a tourniquet or any other means, is also especially objectionable in cases of secondary hæmorrhage of ulcerative or sloughing origin. Pressure will generally have to be applied as a temporary measure in the first instance when the bleeding occurs, but its prolongation should be avoided as far as practicable, so that the production of venous congestion among the weakened structures may be avoided. Digital pressure, applied to the main trunk until more efficient surgical steps can be taken, is the least hurtful; but the sooner the bleeding vessel is fully exposed to view, and the orifices secured by ligature, the better. When once secondary hæmorrhage has occurred to any considerable extent, and the evidence sufficiently points to the bleeding having come from a vessel of considerable size—even though the flow may have spontaneously ceased or have been stopped by remedies of a temporary kind in the absence of the surgeon—the wound should be opened up as soon as practicable, and the bleeding vessel secured. The hæmorrhage will otherwise, not improbably, recur in the night, or at some other time when surgical help is not at hand, and a fatal result may speedily ensue. If there is sufficient evidence to show that the bleeding has not proceeded from a vessel of considerable size, and if it have stopped

at the time of the arrival of the surgeon, delay is allowable, for the arrest of the flow of blood may in such a case prove to be permanent under proper care and ordinary treatment; but, under the opposite circumstances, the delay may lead to fatal consequences, and is, therefore, unjustifiable.

Secondary hæmorrhage, the result of constitutional causes, such as scorbutic deterioration, peculiar states of the blood in which its red particles are deficient, and its power of coagulation and plasticity lessened, is the most difficult of all kinds of bleeding to control. If the original wound be deep and of a severe character, secondary hæmorrhage occurring from large vessels can rarely under such circumstances be treated with permanent success by ordinary expedients. The artery itself is probably in an unsound condition, its coats softened or abnormally thin, and even though the application of a ligature may stop the bleeding for a time, the ligature soon ulcerates away through the outer tunic of the vessel and becomes detached. The debilitated state of the patient's constitution having prevented the healthy protective action which might have taken place under other circumstances, the bleeding then recurs, and the patient's life is placed in still greater hazard than ever. Under such circumstances it becomes an anxious question for the surgeon to decide whether the safety of the patient will not be best ensured by immediate amputation of the injured extremity. The extent and gravity of the wound, the state of the limb, the degree to which the constitutional powers of the patient are reduced, and the opportunities of watching the patient and of giving him due care and attention—hygienic and dietetic conditions being included in this last point—must all be well considered before a decision can be made on the proper treatment to be pursued in each particular instance. The same difficulties are presented in considering the treatment necessary for secondary hæmorrhage proceeding from wounds in limbs, the large veins of which have become obstructed by thrombosis; and also for that occurring in stumps after amputation. As a general rule the hæmorrhage is more under control in stumps after amputation, because the whole face of the wound can be thoroughly exposed to view; but even in these cases, when the circulation of the limb is obstructed above, or when from the unhealthy state of the patient's constitution the stump shows a disposition to slough, or the arteries become opened by extension of ulcerative action to them, the attempts made to arrest the hæmorrhage will sometimes prove fruitless. The question of re-amputation will then arise, or of ligature of the principal artery of the limb with a view to giving time for the patient's health to improve and the stump to get into a more healthy state. Mr. Guthrie has advised that in such a case the shortest distance from the stump at which compression of the artery commands the bleeding should be carefully noted, and that

at this spot a ligature should be applied, provided it be not within the sphere of inflammation of the stump. If this plan prove unsuccessful, then recourse must be had to amputation.[38]

Treatment of maggots in gunshot wounds.—When circumstances favourable to wounds becoming infested by maggots present themselves, the treatment to be adopted divides itself into two parts: firstly, preventive treatment, to avert the access of flies to wounds which are still free from this offensive complication, and of more flies to those already infested; and secondly, treatment for the purpose of ridding the latter of those maggots which already encumber them.

Simple attention to cleanliness and care in the application of dressings do not suffice as a prevention to the deposition of ova in wounds when patients are surrounded by flies in large numbers. Special precautions must be taken to ward off the insects, or they will certainly at some unobserved moment find access to the sore surfaces. The ova, when deposited, are not seen, and maggots suddenly appear in the most unexpected manner. It has sometimes been found advantageous, when camp flies have abounded in great numbers, to protect all the wounds under treatment by placing over the dressings directly applied to them linen which has previously been steeped in a solution of creasote. Carbolised oil, or a moderately strong aqueous solution of carbolic acid similarly applied, will answer the same purpose. The carbolic acid solution can be used of greater strength as a protective over the other dressings than it could be, with impunity, if placed in direct contact with the wound or neighbouring skin. Weak solutions of 1 part in 100, such as are usually employed in direct dressings, are of no avail in warding off flies. During the Crimean War, cotton gauze net was issued for use in the hospital tents and huts as a protection against these insects. It was laid over the parts of the body where the wounds were situated, whenever these were exposed to the air; and as the flies, though not able to get at the wounds themselves, have the habit of hovering about the beds and persons of the patients, the net was also used for covering the faces of the patients to enable them to get rest and sleep. The following modes of treatment are stated in the official surgical history of the Crimean War to have appeared to have been the best employed. To prevent the deposit of the eggs, linen moistened with a weak solution of chlorinated soda or zinc, or with a solution of creasote in water, in the strength of two drops to the ounce, with or without a small quantity of acetic acid, was laid loosely over the dressings, and removed from time to time without disturbing the wound. These applications were found to be adequate protectives. To destroy the larvæ, the same creasote solution, or a somewhat stronger lotion of the chlorinated liquor than that employed for the first purpose, was applied directly to the wound. Some sur-

geons adopted the plan of sprinkling calomel over the surfaces of the infested wounds, but this practice was attended with the risk of tainting their patients with mercury, while the two lotions, previously mentioned, were found quite effectual. If the stimulating effects of the lotions were likely to be hurtful, this was in a great measure obviated by allowing clean tepid water to run over the sore surfaces after their application, before the completion of the dressings. Certainly the treatment by dusting calomel over the wounds is an objectionable as well as an unnecessary proceeding. Dr. Brougham, whose vivid account of the distressing annoyance caused by the multiplication of flies and maggots in the hospitals during the siege of Delhi has been elsewhere referred to, states that he found the application of lotions containing oil of turpentine and camphor the most efficacious treatment against them.

When larvæ burrow, and they will sometimes do so to a considerable distance, injections must be employed. These will cause them to approach the aperture of the wound, whence they must be removed by the aid of a forceps. On one occasion I had under my care in India a superficial wound of the head. It was progressing favourably, when at one of the morning visits I discovered to my astonishment that the whole scalp was burrowed in all directions by larvæ. The wound had been regularly dressed twice daily, and my native dressers were all that I could desire them to be. The accidental appearance of one of the larvæ in the wound, first led to a knowledge of the state of the scalp. No more pain or irritation had attended their presence than the injury to the head itself had seemed to account for. The removal of the nuisance was tedious, and recovery was only attained by diligent extraction of the larvæ singly, and by injections with weak solutions of creasote. In the West Indies, tobacco water, under the name of Chigoe water, from its use in destroying chigoes after they have entered the skin, was the usual remedy in my time for ridding wounds of maggots, but it frequently caused much smarting. It is not improbable that flies sometimes find their best opportunities for getting at wounds during night time, owing to the disturbance of dressings from the movements of patients during their sleep. Usually the flies seem to become torpid, and to retire to their haunts, in the cool of the evening and as night approaches, but they resume their activity with sunrise. It becomes important, therefore, to take especial care at the evening visit that the dressings and their protective coverings are well secured on the wounds, so that access of the flies to them may be prevented during the interval which will elapse before the visit in the morning.

Treatment of hospital gangrene in gunshot wounds.—The treatment of hospital gangrene, practised by different surgeons, has varied very much according as they have regarded the disease as principally one of local, or one of constitutional origin. Some

surgeons have placed their chief reliance on the employment of topical, others on the use of internal remedies. The most judicious plan seems to be to combine the two. It is, however, undoubtedly a form of disease in which local applications for the purpose of destroying the morbid action in the wound, and its products, generally appear to be the most manifest and urgent indications. The disease in most instances is so intense in character, and so rapidly destructive, that there is not time for arresting the spread of it by constitutional treatment only.

The first step to be taken by the surgeon must be to remove the affected patients from the sphere of those influences by which the occurrence of the disease has been favoured, if it have not been developed by them. This must be done no less in the interest of the patients themselves, than to prevent the extension of the disease to other wounded men under treatment. As soon as a wound presents the appearances characteristic of hospital gangrene, the patient should be removed to another building and isolated. The isolation should be as complete as possible. Not only should all infected patients be segregated, but the surgeon and attendants placed in direct charge of them should be exclusively employed on this special duty. No communication should be permitted between them and wounded patients in other places. After dressing one patient suffering from hospital gangrene, the hands of the attendants should be bathed in some disinfectant water before manipulating the next patient. None of the utensils used by patients afflicted with the disease should be employed for other patients. In short, isolation should be not merely applied to the patients suffering from hospital gangrene, but it should be extended, within the utmost limits practicable, to all persons in direct communication with them, and to all articles used by them.

At the same time, if possible, it will be better for all the wounded men under treatment to have the advantage of a change of atmosphere. With this view they should be removed from the ward, or wards, in which the hospital gangrene has appeared, and either be placed in tents or huts, or taken to another building in a healthy locality where free ventilation can be secured. This is especially necessary if the walls and floors of the wards in which hospital gangrene has appeared are of an absorbent nature. If this change cannot be accomplished, the unaffected patients who must remain in the wards where the disease has shown itself should be separated as widely as possible from each other, so as to give them the most copious aeration, to prevent contact, and to diminish the concentration of wound effluvia to the utmost available extent.

The most rigid attention to cleanliness; to the prevention of any transmission of infectious matter from patient to patient by the hands of surgeons or dressers, or by means of the articles em-

ployed in dressing wounds, such as tow, water, and others (sponges should never be employed in such cases); to freedom of ventilation; to the immediate destruction of all foul dressings; to the removal of decaying rubbish, stagnant water, and all offensive matters in the precincts of the hospital building, should be insisted upon. The efficiency of the drainage, and all other hygienic requisites, should be properly attended to.

Disinfectants, as the carbolic acid and permanganate of potash, should be used freely, when circumstances will not allow the patients to be removed into fresh air. Fumigations, and antiseptic vapours are thought by some to be very effective in neutralising the pernicious qualities of impure air in wards in which many wounded men are collected, and the development of infectious disease is threatened. Liquid bromine placed in saucers, each containing about an ounce, distributed over different parts of a ward, so that the odour of the bromine may be constantly perceived, has been thought by some surgeons in the United States to be specially energetic as an antiseptic and disinfectant, for the control of hospital gangrene, erysipelas, and allied diseases. The system may be of use in some instances, but it should never be forgotten that disinfectants cannot be other than mere palliatives; they cannot be regarded as efficient substitutes for fresh air. However perfect everything else may be in a hospital—administration, curative treatment, nursing, cooking, &c.,—without a pure atmosphere no wounds will do well; and if the purity be lowered below a certain degree, some infectious disease will almost necessarily be developed as one among many other ill results. Moreover, no reliance can be placed on fumigations, or the dissemination of antiseptic vapours, in apartments in which such diseases as erysipelas and hospital gangrene have appeared. The air which enters the ward from outside may be contaminated by sewage emanations or other noxious effluvia; and, in such a case, to limit efforts to purifying the atmosphere within the ward by the occasional employment of fumigation or other similar means, would leave the principal, and all the more serious because constantly acting, evil untouched. Where there is good reason for concluding that no such surrounding impure atmosphere exists, and the purpose is simply to purify the interior of a ward, in which a large number of wounded patients have been lying, before others are received in it, the dissemination of some of the usual disinfecting fumes may be combined with other means of cleansing the apartment with advantage.

A very large variety of substances, escharotic, antiseptic, stimulant, and sedative, have been employed as local remedies in hospital gangrene. Among British surgeons the undiluted mineral acids, especially the nitric acid, and the liquor arsenicalis, are the two remedies most employed. When one of the strong mineral

acids is used, the parts surrounding the gangrenous tissues should be protected by a thick layer of ointment, the sore freed from the sloughs and moisture as much as possible by means of a pad of tow, and the acid applied steadily to the surface until it is caused to be insensible and presents the appearance of a tough fibrinous mass; until, in short, the qualities of its substance are completely destroyed. Lint wetted with diluted carbolic acid lotion should then be laid over the sore as a covering. The acid is most conveniently applied by means of a piece of lint rolled round the end of a glass rod. If the diseased action should reappear, the acid must be reapplied. Another plan of using the nitric acid has been to cause it to destroy a circle of skin and subcutaneous areolar tissue around the diseased part, so as to isolate the latter from the sound structures. When the yellow coriaceous slough becomes detached, it will probably carry with it the gangrenous surface of the sore, and the wound may then granulate healthily. This is not so thorough or reliable a mode as the former one. The pain resulting from the application of the acid does not last long; and even this may be prevented by placing the patient under the influence of chloroform, if he be in a fit state to bear its employment.

It is equally necessary to give attention to cleansing the surface of the gangrenous wound before applying the liquor arsenicalis to it. When the sore is cleansed, lint soaked in the arsenical solution, diluted with an equal part of water, is applied to it, and is to be renewed at intervals of half an hour. Mr. Blackadder, who first employed this remedy, and has written with much emphasis on its remarkable efficacy, has stated that the best plan is to continue applying it until an insensible, dark-coloured, dry slough is formed upon the whole surface of the sore, and the patient becomes relieved of pain.

Various other caustic substances have been occasionally employed for the purpose of destroying the morbid influence and stopping the further progress of the gangrene: concentrated solutions of chloride of zinc, of permanganate of potash, potassa fusa, acid nitrate of mercury, perchloride of iron, sulphate of copper, red oxide of mercury, creasote, powdered camphor, and others. Bromine, in its pure liquid form as well as in combination with bromide of potassium, was largely employed during the United States' War, and is described as having proved extremely beneficial in arresting the ravages of the disease. As this very powerful disinfectant was first used in the treatment of hospital gangrene at that time, and as its employment has been regarded as a special boon to military hospitals, it may be useful to quote the directions as to the mode of applying it given by Dr. Goldsmith, U. S. Vols., to whom its successful application as a topical and prophylactic agent for the control of this disease is stated to have

been chiefly due.[39] They are as follows :—'The parts are first to be dried by the application of charpie; then the sloughs, if thick, should be trimmed out with forceps and scissors as much as possible, for the thinner the slough the more effectual is the remedy. The parts having again been dried, the solution is applied by means of a mop, or a pointed stick of wood, in quantities sufficient to saturate the sloughs. If the sloughs undermine the skin, or dip down into intermuscular spaces, the solution must be made to follow, with the pointed stick, or by means of a glass syringe.

'If the application has been effectual, all odour from the diseased surface ceases, and the sloughs become somewhat hardened. The remedy should be reapplied every second hour as long as any odour of putrefaction is present, or as long as the sloughs appear to be diffluent. It is not always necessary, especially when the sloughs are diffluent and thin, to use the solution in its full strength; it may be weakened by the addition of water as the disease subsides.

'The solution should be applied in strength and frequency sufficient for the impregnation of the whole of the sloughs. If the sloughs are thick and cannot well be trimmed, the bromine may be introduced into the thickness of the slough by means of a hypodermic syringe.

'After the topical application of the solution, the parts, when so situated as to render it practicable, should be subjected to the influence of the vapour. A piece of dry lint is to be placed over the diseased part; over this is to be placed another piece of lint moistened with the solution of bromine; over this a third piece spread with simple cerate; the whole to be covered with oiled silk and bandage, so arranged as to retain the vapour in contact with the diseased surface as long as possible.'

Continental surgeons have generally preferred the use of the actual cautery. It was largely employed during the late Franco-German War by the German surgeons. The reports regarding it have tended to show that hospital gangrene may be arrested by this form of remedy with more certainty than by any other. The irons are applied at a red or even white heat. In using the actual cautery, as all other caustics, it must be remembered that the object is to penetrate completely the parts affected with the gangrene, and to destroy a layer of the sound tissues beneath. If any poisoned portion be allowed to remain untouched, the disease will very probably spread from that point. The surgeon must have a full conviction of the necessity of such complete destruction of the diseased structures to enable him resolutely to burn the tissues to the requisite depth. As the iron, though red-hot when applied, soon becomes cooled by acting on the moist pulpy tissue, and as this layer is more resisting to the burning action of the cautery than might at first be supposed, it is necessary to have

several cauterising irons ready for use in each case. They should be applied to the wound while the patient is narcotised by chloroform or ether. In cases where a large surface has to be cauterised, it is convenient, in the first instance, to remove as much as possible of the pulpy gangrenous tissues, and then to dry the surface as far as practicable with some tow. Portions of the edges, if much undermined, may also be cut away with advantage before the cauterising irons are applied.

On the other hand, notwithstanding the recorded experience of Dupuytren, Delpech, and other eminent French surgeons who have regarded the actual cautery as the most promptly and constantly successful of all local remedies in hospital gangrene, according to reports by Dr. Reeb respecting the treatment of hospital gangrene in the French Military Hospital at Strasburg, and by Dr. Bongard, respecting its treatment in Belgium, during the war of 1870-71, quoted by Dr. Chenu,[40] the employment of the actual cautery failed in their hands to arrest its progress. Both of these surgeons have reported that they had better success with the simple application of lemon-juice. The juice was applied by pads of charpie two or three times a day. The use of the actual cautery is also stated to have been attended with but little success in the treatment of hospital gangrene at Paris, where the disease prevailed to a great extent during the siege.

Whatever kind of caustic applications may be used, when the charred tissues and sloughs have become detached and a fresh granulating surface obtained, the ulcer may then be treated with any of the usual antiseptic dressings; the previous condition of disease in the part appears to exercise no influence upon its future progress, when once the morbid action has been checked.

The constitutional treatment must vary with the varying states of patients. Some surgeons have strongly advocated the administration of an emetic on the first signs of an approaching attack of hospital gangrene being observed.[41] The necessity for giving an active purgative in the onset of the attack has also been generally noticed. The careless habits of soldiers frequently render attention to a thorough evacuation of the bowels necessary before resorting to the use of other remedies. The excretions, as well as secretions, are particularly liable to be disordered both at the time of the invasion and during the progress of the disease, and their regulation becomes a necessary part of the treatment. The administration of iron, quinine, or one or other of the mineral acids, is generally serviceable. Pain must be alleviated, excitement allayed, and sleep procured by the free administration of opium in some of its forms or by other sedative remedies.

Venesection was formerly said to have been very beneficial when much fever existed. It was combined with other antiphlogistic remedies. The removal of a moderate amount of blood may

prove occasionally useful, when men in a state of good general health with slight wounds happen to be attacked by the disease, and when the disease manifests itself in an active and sthenic form, but it is rarely if ever now resorted to by English surgeons. Other means, as antimonial preparations, and medicines of a like character, are preferred for lessening the constitutional and local excitement. Certainly no one would now practise venesection to the extent to which it was recommended by Staff-Surgeon Dr. Boggie,[42] whose advice and example seem to have led to bleeding becoming a favourite treatment among many surgeons of the Peninsular period.[43] Hennen has recorded that the practice of venesection, introduced by Dr. Boggie, became general between the months of October and March in the treatment of the Bilboa hospital gangrene, and that it was regarded both by surgeons and patients as very advantageous. To modern surgeons it seems only reasonable to conclude that the greatly lessened ratio of mortality in hospital gangrene at the present day, compared with what the records show it to have been during the Peninsular war, may be greatly due to the abandonment of the practice of bleeding for its relief.

The records of the disease and its treatment, handed down to us from the time of the Peninsular war, lead to the inference that the general characters of hospital gangrene were of a much more inflammatory and sthenic type then, than they have been in later wars. It was remarked in Germany that most of the severely wounded Germans, and still more the wounded French prisoners, who were transported from France to the German hospitals, especially if they had been long in the field before receiving their wounds, arrived in a condition of great general debility. The fatigues and hardships of the campaign, the effects of their wounds, the subsequent hospital confinement, the insufficient attention after battles which left overwhelming numbers of wounded in the hands of the surgeons, the too frequent neglect of changes of dressings and regular treatment during the journey, often of three or four days' duration, from France to Germany, reduced the physical powers of the men so seriously, that they usually arrived in a very sickly and depressed state at the German hospitals. Suitable nutrient support, with a moderate amount of stimulants, cautious nursing, and tonic remedies, was the constitutional treatment most urgently demanded. As a general rule, the efforts which have been made to ameliorate the constitutional condition of patients suffering from hospital gangrene in all recent wars have been conducted on similar sustaining principles. When patients in the depressed state, above mentioned, are attacked by this disease, the morbid action, the intense pain, and the loss of appetite with which it is accompanied, quickly reduce them to a still lower ebb; and it requires the greatest skill, and the most unremitting attention to support them through the terrible ordeal to which they thus become sub-

jected. It will sometimes become an anxious question for a surgeon to decide, when life is threatened by the extent of destruction that has taken place in a limb, whether amputation may not hold out a better prospect of saving the patient's life than allowing the strain on the powers of the constitution, in its efforts to repair the mischief which has been effected, to continue. Too frequently, however, when the question arises, the state of the patient is such as to prevent any reasonable prospect of success from the operation.

Treatment of pyæmia after gunshot wounds.—From all that was said in describing this complication, and the circumstances under which it is chiefly observed, it is obvious that preventive measures are of vital importance to wounded patients. If surgeons are still in ignorance respecting many of the phenomena of pyæmia, and in some respects of its true nature, at any rate, a knowledge of the conditions which are generally found to lead to the production of this fatal disease enables them to become aware of the precautions which may be taken to prevent its occurrence. If a low degree of vital energy, whatever the source of it may be, predisposes patients to the reception of pyæmic poisoning, regular and sufficient nutritious diet, cheerful occupation of the mind, adequate clothing, and a proper amount of rest, are indicated to fortify the constitution against the effects of exposure to it. If the septic influences of miasmata arising from patients with suppurating wounds tend in a manifest and chief degree to the development of pyæmia, we can counteract, or at least partly ward off, their poisonous effects by taking steps to remove the emanations as fast as they arise, before they have time to become corrupt and hurtful, and by separating patients with such wounds as far apart from one another as practicable. Free ventilation, and attention to all the sanitary precautions which have been mentioned when describing the preventive treatment of hospital gangrene, are equally necessary for warding off this complication. The general excitement in time of war, the circumstances of battles, the frequent occurrence of death from causes so much more obvious to the commonest senses than that arising from the slow poison of an impure atmosphere, the sudden admission into hospitals of many wounded men together, the many demands on the time and exertions of attendants, are apt to render persons in the midst of such scenes regardless of what appear to be comparative trifles; and among the other duties of surgeons in warding off this complication, not the least imperative will be regular personal observation to ascertain that the directions given in hygienic matters are really carried into execution. Surgeons can rarely place dependence on the statements of military subordinates in respect to such subjects.

But when pyæmia is apparently approaching in a given case, or when manifestations of its presence already exist, the attention and special care of the surgeon should at once be directed to the

state of the wound, and to the patient's general condition. Both local and general treatment should be tried without delay.

Local treatment.—If the discharge of pus have become scanty, the wound should be well fomented, some warm dressings of a simple character applied, and any other steps should be taken that may appear calculated to restore free action in the suppurating surface, without exciting irritation of any kind in it. If the wound be deeply seated, frequent and complete removal of all accumulated pus by gentle means should be diligently attended to. Topical applications, by injection or otherwise, which may hold out a hope of improving the tone of the secreting surfaces should be employed. For this latter purpose any of the ordinary astringents may be used of moderate strength. Weak solutions of the permanganate of potash have appeared beneficial in this respect. The perchloride of iron was much used in the Italian campaign of 1859, as an application to wounds in cases attended with threatening of pyæmic poisoning, and the effects were stated to be exceedingly satisfactory. If the suppurating wound be connected with fracture of bone in one of the limbs, and all reasonable hope of union seems to be frustrated by symptoms of pyæmic cachexia having manifested themselves, the question of amputation will arise. It is a question that can only be decided after a complete investigation of all the circumstances, local and general, of each particular case. As a general rule, however, if pyæmia has really commenced, and especially if it has assumed an acute character, the patient is no longer in a fit condition to be subjected to amputation. The shock of the operation is more than he can bear with impunity; and, even if the first dangers be escaped from, a healthy reparative action cannot be anticipated. Sir James Paget has, however, pointed out in his clinical lectures that in *chronic* pyæmia, when an injured part is manifestly useless, or is a source of irritation or of exhaustion to a patient, amputation may be a very proper operation to be performed.

When joints become distended with pus, they should be treated as pus in joints under other circumstances, especially by easy support, rest, and the maintenance of an equable temperature about them by means of cotton-wool. The fluid may be removed by the aspirator, or under the antiseptic spray, with advantage. Equally, if purulent collections take place among the soft tissues near the surface of the body, the pus should be evacuated with similar precautions.

Constitutional treatment.—The general indications are, first and foremost, to remove the patient out of the building in which the septic influence has been exerted into a fresh atmosphere, into a tent on suitable ground, if practicable; to try and remove by appropriate remedies, or by exciting some of the excretory organs, any injurious products which may exist in the blood; to support

the strength of the patient to the fullest practicable extent by nutritious food in a form likely to be assimilated readily, combined with the moderate use of stimulants; and lastly, by the administration of quinine in full doses, mineral acids, and other tonics. The remedies last named appear to be useful in checking the rigors and the copious perspirations with which the disease is usually attended. If nervous irritability be a prominent symptom, opium is the remedy which can be most relied on for allaying it. It has been recommended to encourage pyæmic patients to take tepid drinks copiously, with a view to maintaining fulness of the vessels, so as to render them less likely to absorb matters of a noxious character into the system. Whether this injunction has any practical value is very doubtful.

Just as the perchloride of iron has been strongly praised as a local application, so also the beneficial influence of its internal administration has been highly extolled by Continental surgeons. It is given in rather full doses, twenty minims every 3 or 4 hours, and is employed as an internal remedy at the same time that it is used locally.

The hyposulphites of soda and potash have been extensively tried by some surgeons as medicinal agents in pyæmia; but there is no sufficient evidence to prove that they have ever succeeded in controlling the constitutional symptoms, while they have often seemed to lead to derangement of the digestive organs, as well as to diarrhœa to a debilitating extent.

When visceral pyæmic abscesses have been once formed, there are no special means of helping the patient known. The general treatment which has been already mentioned should be still employed, in the hope that, by averting further noxious influence, and by supporting the patient's strength to the utmost extent practicable, time may be gained and an opportunity for natural cure be afforded. But at this stage the disease is so generally fatal, that the importance of preventive measures is all the more strongly forced upon the attention. It is the only part of the treatment on which a surgeon can reasonably place firm reliance. I cannot say that I have ever seen any remedies successful when a wounded patient has been invaded by this complication in a decided degree. I have seen patients with gunshot wounds in whom a tendency to pyæmia has existed, or in whom what have been regarded as early pyæmic symptoms have actually shown themselves, recover under careful and judicious treatment; but I cannot recall to mind an instance of recovery of a patient in whom pyæmia has been fully developed beyond all doubt.

Treatment of tetanus after gunshot wounds.—The diminished number of cases of tetanus relatively to the number of wounds in recent as contrasted with former wars, occurring as this diminution has done, as a rule, concurrently with better hospital arrange-

ments and greater attention to hygienic matters, appears to indicate the efficiency of preventive treatment in lessening personal susceptibility to attacks of this disease. The sanitary precautions, therefore, which are acknowledged to be useful in warding off other complications of gunshot wounds, should also be regarded as one important means of averting the probable occurrence of tetanus among wounded patients. The particulars of this hygienic preventive treatment, and the precautionary measures specially calling for attention in military hospitals, have already been mentioned when laying down rules for the general treatment of gunshot wounds, and also when describing the preventive treatment of some of the complications which have been already noticed, and need not be repeated.

Excessive alternations of temperature at comparatively short intervals of time, as between the day and night, especially when associated with a damp state of the atmosphere, have been so often noted as circumstances favouring the occurrence of tetanus, and subjection of parts of the body to currents of cold air has been so frequently observed to increase and intensify the symptoms in patients suffering from it, that, not only as a precautionary but also as a remedial measure, the wounded patient should be carefully protected from exposure to such atmospheric vicissitudes. The maintenance of an even temperature, and of a dry atmosphere, in the places in which wounded men are treated, and especially in which any patient who exhibits signs of approaching tetanus is placed, are objects which all surgeons in charge of hospitals should seek to attain. If a wounded man, placed in a gallery or in a corridor of a building, or in any situation particularly exposed to currents of air, especially night air, complains of stiffness about the face or neck, or exhibits any commencing signs of nerve irritation, he should be at once removed to an apartment where he can be protected from such influences.

Curative treatment.—When symptoms of tetanic irritation become manifest, the surgeon's attention must be given to the state of the wound, and also to that of the constitution of the patient, as in other complications. Efforts should be made, without any delay, to remove the irritation at its source; for there is reason to believe that the earlier this can be effected, the greater will be the chance of arresting the advance of the diseased action.

Some of the examples mentioned in the general remarks on this affection have afforded evidence, on examination after death, tending to show that the lodgement of foreign bodies, such as pieces of cloth and fragments of projectiles, have been the origin of the evil; while other examples have seemed to prove that the abstraction of similar sources of irritation may occasionally stop the progress of the disease, after tetanic spasms have been exhibited. The wound, therefore, if it be suppurating, should be cautiously

and thoroughly examined for any lodged substances that may be remaining in it. If it be deep and tortuous, or if the projectile has left a long sinuous track, the irrigator should be diligently employed, but, at the same time, without roughness; with a view to flush away any pieces or fibres of cloth that may have been caught and be lying in some part of the wound. Should any such extraneous substances have acted as the prime cause of the irritation, their removal will afford the best hope of the nerve excitement subsiding and a cure being eventually obtained. As soon as the wound is cleared of all foreign bodies, it may be bathed with some warm anodyne fomentations, and lint, moistened with an opiate solution and covered by oiled silk, may be left on it as a dressing. The guiding principles in treating the wound should be to preserve an equable temperature of the parts about it, to keep it in as easy a posture as practicable, to prevent all pressure and irritation in any shape, and to apply only such dressings to it as shall exert a soothing influence. If there be any constricting bands of tissue about the wound, these should be divided before the dressings are applied, so that all the parts may be kept as free from tightness and restraint as possible. The importance of preserving an even temperature about the patient has been referred to elsewhere, and the advantage of maintaining an equable temperature of the wound itself has just been mentioned. Dr. Chenu has stated that in the Italian war the use of tow in enveloping wounded parts which were painful and sensitive to the impression of cold at night time, though a simple matter, proved itself a means of help which ought not to be lightly rejected. 'Under the influence of tow so applied,' Dr. Chenu remarks, 'and of opiate dressings, we have seen commencing symptoms of tetanus rapidly disappear.'[44]

In the *post-mortem* examination of a stump in a case where tetanus carried off a young officer whose arm had been amputated for a gunshot wound after the battle of Eylau, Baron Larrey found the median nerve included in the ligature of an artery; and this circumstance, together with other like observations, led him to think that the inclusion of nerves might be a frequent cause of tetanus after amputation, especially when the ligature had not been drawn tight enough to effect complete strangulation of the nerve. This distinguished French surgeon relates that, turning this experience to useful account, he averted in several instances, on the first appearance of symptoms of tetanus, the full development of the disease by passing a grooved director carefully between the artery and the ligature, and dividing the latter. In all similar cases, therefore, it will be prudent for the surgeon to ascertain whether a nerve has been accidentally included in a ligature, and, if so, to release it as above described.

'The complete division of the smaller branches of nerves, which

have been lacerated or otherwise injured in gunshot wounds, has in some rare instances seemed to arrest the disease after trismus, and symptoms of the approach of general tetanus, had shown themselves; but in many other cases the plan has totally failed. Equally, amputation and reamputation have been tried by many military surgeons in cases of tetanus occurring after gunshot wounds in the extremities, but when the disease has presented itself in an acute form, the operation seems to have invariably proved unsuccessful; in some instances, when the subacute form of the disease only has existed, the operation has succeeded. But other remedies of a less severe character have succeeded in similar cases.

The performance of amputation as a means of cure cannot, therefore, be recommended in any case where tetanus has fully established itself. It has now become a constitutional and general disease, the nervous centres are fully involved in it, and there can be no reasonable ground for expecting that the local amputation can put a stop to it. On the other hand, if the disease present itself in a very limited degree, and in a subacute form, in simple trismus, or trismus only associated with stiffness of some of the neighbouring muscles, it does not appear justifiable to resort to a large amputation as a means of cure only; milder remedies may be as successful as this serious operation; but if the state of a wound in one of the extremities be such as of itself partly to justify the amputation, then the hope of arresting the irritation at its source, and, with it, the commencing general tetanic symptoms, will render the operation a justifiable and proper proceeding if the patient be strong enough to bear it. Dr. Chenu has recorded three instances in which the operation of amputation was performed above the parts wounded, during the Italian war, in order to arrest tetanus, but without obtaining cure, or even amelioration of symptoms.[45] It has been mentioned, however, that during the United States' War, two cases of recovery from tetanus took place after amputation of the wounded part, and that in these cases the 'symptoms were very grave.'

Constitutional treatment.—The early administration of an active purgative, such as a dose of calomel or croton oil, which can be given even if there is some difficulty in swallowing, or the exhibition of a full turpentine or other enema, to relieve the lower bowel of any accumulations, is generally an advisable proceeding. Constipation is a usual accompaniment of the disease, and must be counteracted by suitable remedies.

The special remedies that have been tried empirically in tetanus have been most numerous, and they have been administered in an endless variety of doses. Opium administered internally, hypodermically, or smoked, camphor, chloral, strychnia, cannabis Indica, Calabar bean, alcoholic stimulants, chloroform, digitalis, belladonna, aconite, atropine, mercury by the mouth and frictions to salivation,

quinine, chloride of barium, may be mentioned as being among the number, but many others have been used. The very variety serves to prove how little reliable any one of them has been found to be. Surgical proceedings, such as the application of irritants and cupping along the spine, with a view to relieving congestion of the spinal cord, and the application of the actual cautery, have been made use of, but have generally failed to make any permanent impression on the disease. Venesection was employed to a considerable extent during the Italian campaign, but it produced no amelioration of the symptoms.

The following *résumé* of the treatment of tetanus adopted by the United States' surgeons is given in the preliminary Surgical Report of the United States' civil war, published in 1865. 'The great majority of cases were treated by the free use of opium, conjoined with stimulants and concentrated nourishment. Chloroform inhalations were very generally employed during the paroxysms of spasmodic contraction. Subcutaneous injections of the salts of morphia and atropia were frequently used. Cathartics, quinia, camphor, cannabis Indica, bromide of potassium, strychnia, belladonna, and aconite are mentioned among the remedies employed. Cups, blisters, turpentine stupes, and ice were among the applications made to the spine; and fomentations with opium or tobacco were sometimes applied to the wound. Amputation, the division of nerves, and the extirpation of neuromata in stumps were the surgical measures sometimes employed.'[46]

The inhalation of chloroform or ether, although it does not appear to have arrested the ultimate result of the disease, has, according to general testimony, been frequently serviceable in causing a temporary mitigation of the violence of the spasmodic contractions. Dr. Bima, Divisional Surgeon in the Sardinian army, has mentioned that in some cases of tetanus observed by him during the Italian campaign of 1859, the wounded men urgently begged for a repetition of the chloroform when once they had been subjected to its effects.[47] Unfortunately, as a general rule, as soon as patients cease to be under the influence of such anæsthetics, the muscular stiffness, and then the spasms, return.

Curare was employed as a remedy in some cases during the Italian War of 1859. It was brought into special notice by a successful result obtained from its administration by M. Vella of Turin, in a case of acute tetanus following a bullet wound of the foot, in which one of the metatarsal bones was broken, inflicted at the battle of Magenta. The wounded man arrived at Turin on June the 7th. Commencing trismus, with difficult and somewhat painful deglutition, showed itself ten days afterwards. The next morning trismus was complete, in the course of the day tetanus became general, and in the evening the tetanic spasms were violent and very painful. A strong solution of curare was at once applied to the wound, and

a calming effect speedily produced. After a short time, as the absorbing power of the surface of the wound seemed to be lessened, small blisters were raised in succession, and these were dressed with the curare. According to the description of Principal-Surgeon Dr. Isnard, who watched the case, the tetanic spasms were suspended after each dressing. The wound was dressed by the curare five or six times in the twenty-four hours, and the dressing was always followed by calm and sleep. Under this treatment the spasms gradually diminished in intensity, the patient was enabled to take nourishment, and, in about a month from the commencement of the attack, all the tetanic symptoms had completely disappeared. The wounded man left shortly afterwards for France. The curare had been tried in three cases previously; but, although in these cases the calming effects of each application were strongly marked, as soon as the action of the medicine was expended the painful tetanic spasms returned with the same violence, and only disappeared for a time when the curare was again applied. The strength of the watery solution of curare employed in the successful case is not stated; it was applied to the wound by means of charpie moistened with the solution. Among the cases of tetanus, occurring among Austrian, French, and Sardinian soldiers in the war of 1859, tabulated by Dr. Demme, the only case noted as having been treated by curare is the case of M. Vella before mentioned.[48] The Surgeon-General's report, before quoted, mentions that curare was not used in the treatment of tetanus during the United States' War, but it refers to a statement by Dr. Demme ('Schweiz. Zeitschrift für Heilkunde,' ii. 356) that out of twenty-two cases of traumatic tetanus which had been treated by curare eight had recovered. The production of copious and prolonged diaphoresis by hot air or vapour baths, warm drinks, &c., has occasionally afforded much relief to patients, and in some instances has appeared to assist in effecting a cure. Dr. Reeb has recorded two cases of recovery at Strasbourg during the late Franco-German war, in which vapour baths, combined with hypodermic injections of morphia and the administration of stimulants, were the remedies employed. But in these two cases the disease was of a chronic character, was confined to trismus, stiffness of neck, and some difficulty in swallowing, neither the limbs nor the trunk being invaded by spasms; while in the instances of ten other wounded patients who became subjects of tetanus at Strasbourg the same remedies were employed, but all terminated fatally.[49] Three other successful results during this war are reported by Dr. Chenu, in which the production of copious transpiration, together with the administration of chloral, were the remedies employed. But they appear to have taken place in patients in whom the disease did not assume a violent or general character.

Attention has recently been called to the use of nitrite of amyl

in arresting tetanus. It seems to have been given in several cases with successful results. In three the nitrite of amyl was combined with other remedies, so that the value of this drug could not be distinctly determined; but in one case, in which acute tetanus followed extensive burns of the body and extremities by hot iron blown against the patient from a foundry, the nitrite of amyl was given alone and the patient ultimately recovered. The case is related at full length in the 'Philadelphia Medical Times,' of June the 12th, 1875, by Dr. Wm. S. Forbes. The tetanic symptoms began on the fourth day after the injuries, and advanced to general spasm, especially opisthotonos, of a severe description. The use of the drug was begun on the evening of the sixth day, forty hours after the first signs had shown themselves. It was given in doses of three drops, subsequently increased to five drops, inhaled twice daily. When omitted for two days, the eighteenth to the twentieth of the disease, the man grew rapidly worse: while, on being again used, the patient experienced speedy relief, and from that time progressed steadily to complete recovery. The amyl was discontinued on the forty-sixth day after the first dose was given. The patient had inhaled, altogether, one ounce of the drug.

The records of military observations of tetanus have unhappily tended to confirm the experience of the disease as it has been met with in civil practice. In its subacute form there are occasional recoveries under various kinds of treatment; in its acute form, when it occurs early after gunshot wounds or amputation consequent on them, and when the spasms spread from one set of muscles to another in rapid succession, no kind of treatment can be said to have proved itself of special avail. Even in instances where recoveries have occurred, it has been difficult to determine, with certainty, what part in the cure the remedies administered have had. The cure may have been equally attributable to subsidence of irritation from natural causes, so frequently have the same remedies, which have appeared to be beneficial in the successful instances, been tried in others and followed by fatal results.

Treatment of erysipelas after gunshot injuries.—The remarks which have been made on the preventive treatment of hospital gangrene; on the importance of removing the subject of it from the place where the disease has been contracted, and of isolating him from other patients; of removing other wounded patients who are free from the complication into a fresh atmosphere in tents or elsewhere, especially men who are necessarily confined to bed from the nature of their wounds, and are, therefore, constantly breathing the air of a single apartment; and the description of the hygienic measures to be adopted, and the attention to be given to other means of preventing the spread of the hospital gangrene by accidental inoculation or otherwise, are equally applicable to the complication now under notice. No patient who has become the

subject of erysipelas should be allowed to continue in the same tent or apartment with other wounded men. If it be permitted, the spread of the disease to the other patients may be regarded as almost certain.

In treating erysipelatous patients, a little consideration of the circumstances under which the disease has too often made its appearance, will suffice to show the necessity for taking precautions to prevent the aggravation of its character by allowing the atmosphere around the patients to become stagnant, or by exposure of them to any other of the sources of contaminated air which may occasionally occur in stationary hospitals. Erysipelatous patients can be best treated in tents; for in tents, with good management, there can be ensured the most thorough ventilation, almost the same purity of atmosphere as outside, and at the same time all needful protection from changes of weather. A constant supply of fresh and pure air is as necessary in the treatment of the disease as it is for its prevention.

Wounded men convalescing from an attack of erysipelas should be placed apart from men recently attacked by the disease. It has been noticed that where this rule has not been enforced, relapses among the convalescents have been a common occurrence.

Simple erysipelas, if hygienic necessities be duly attended to, requires but very slight treatment, either constitutional or local. There seems to be an inherent disposition in the mild form of the disease to pass through its successive stages without exciting much constitutional disturbance or local mischievous consequences. A suppurating wound, in a healing condition and in a soldier in a good state of general health, may chance to become the centre of an erysipelatous attack; but if the patient be surrounded by a pure atmosphere, the administration of a simple purgative, a temporary restriction of diet, and the local application of some slight soothing and protective remedies, such as powdering the surface with finely levigated chalk, or ordinary wheat flour, and maintaining an equable temperature by enveloping the parts concerned in cotton-wool, will often quickly cause the active and spreading character of the disease to cease. In a few days the redness will disappear, and the desquamative action ensue without further trouble.

But when large and lacerated wounds are attacked by erysipelas, especially if the disease be endemic at the time, or when it attacks wounded men who have been previously depressed by much fatigue and exposure, or whose constitutions have been deteriorated by the unsanitary influences of ill-conditioned hospitalisation, the disease usually assumes a more virulent character. Great care and active measures now become essential to restrain it within bounds, and to ward off the threatened destructive consequences to the areolar and other tissues in the neighbourhood of

the wound, as well as to guard the patient against the effects of the great prostration by which the attack will certainly be followed.

The treatment of erysipelas naturally divides itself into constitutional and local treatment, as it does in other allied diseases.

Constitutional treatment.—In the treatment of almost all men whose wounds are attacked by erysipelas, it is well to commence the constitutional treatment by administering an active purgative. Some surgeons advocate the employment of an emetic at the onset of the disease, and, if the frame of the patient be vigorous, and the action of the medicine be followed by copious draughts of warm water so as to bring on profuse diaphoresis, the effect will probably be very beneficial; but otherwise, it may increase depression, and do harm. If the wound be a comparatively recent one, and if the patient has not been weakened by much loss of blood, long confinement in hospital, or any other depressing influence, a purgative dose of calomel followed shortly by a cathartic draught, will generally prove beneficial, by removing whatever accumulations there may be in the bowels, by relieving the digestive organs and inducing healthy secretions from them, and by placing the patient in a better condition for the reception of future remedies. If the patient be reduced from previous hæmorrhage, profuse or prolonged wound discharges, great pain, or any other cause, at the time of the attack, a milder form of purgative should be adopted.

For the succeeding two or three days no better medicine can be given to the patient than a saline mixture, at intervals and in doses sufficient to maintain an action of the bowels, in combination with a mineral acid. If the fever be very high, diaphoretics should be administered, and the use of the mineral acids delayed until a later date. These remedies should be followed by some of the preparations of iron, which seem to exert a special influence on the disease. The tincture of the sesquichloride in doses of 25 or 30 minims in a little water every 3 or 4 hours is one of the most usual and convenient forms of the remedy for military hospitals. It sometimes produces a very marked beneficial effect: diminishing the intensity of the local symptoms, and seeming to prevent the spread of the disorder, as soon as a few doses have been taken. Other salts of iron are occasionally given.

The patient's strength should be maintained throughout by abundance of nutrient support in the form of beef essence, milk, and any light articles of food he may feel inclined to take. In some cases of erysipelas occurring in chronic wounds, the very fact of the attack is indicative of a susceptibility to the disease from a weakened state of constitution, while the erysipelas itself acts as a cause of additional prostration. The support of the strength of the patient is then a matter of extreme importance, not merely for restraining local destruction of tissue in the

parts where the disease has appeared, but also for the preservation of the life of the patient himself. This can only be accomplished by judicious and careful nursing; on the one hand, by not giving food either in quality or quantity beyond the power of digestion, for undigested food in the prima via must become a source of irritation and indirectly of weakness; on the other hand, by giving food of such a kind and in such a manner that it may be converted into true nourishment. The condition and habits of the patient, and, to some extent, his own fancies, must be taken into consideration when determining the forms of diet most appropriate to his case: as a rule, only light forms of nourishment can be tolerated in the early part of the attack, and that only in limited quantities at a time. When thirst is troublesome, it may be allayed with advantage by some of the acidulated drinks, especially the lime and lemon juice drinks. The exhibition of ipecacuanha wine in water, in very small doses of four or five drops at regular intervals of one or two hours—not in quantity enough to produce any nauseating or depressing effect—has sometimes seemed to me to afford the best means of lessening thirst, at the same time that it assisted in allaying general irritation, and acted favourably on the skin.

Narcotic remedies do not generally seem to be advantageous in the earlier stages of erysipelas, and must always be administered with great caution, especially if any signs of cerebral excitement are present. When erysipelas attacks wounds of the face or head, the patient usually exhibits much torpor and drowsiness, and the disease in this situation is attended with great danger in consequence of the tendency to cerebral congestion. Opiate remedies would manifestly be out of place under such circumstances. But in other situations—in wounds of the extremities—and when there is much nervous excitement with prostration, narcotic remedies should be given, but still with great caution. There seems to be a tendency to cerebral disturbance in the disease independently of local situation. After evacuation of abscesses, and when sloughs are being discharged, when there is much debility, constitutional irritation, and sleeplessness, opium in some of its forms becomes of the greatest value as a sedative, and can usually be administered without any ill results.

In no condition of wounds does the advantage of administering stimulants seem to be so manifest as it is in gunshot wounds, which have been attacked by erysipelas, attended with diffuse cellular inflammation. Wine, or alcohol in any of its ordinary forms, especially if the patient has been in the habit of drinking spirits, or porter, may be given in all such cases with advantage; they 'keep up' the patient in ordinary language, and, when judiciously administered, enable a patient to fight against the prostrating effects of the disease, who would otherwise succumb to its influence.

Local treatment.—The indications for treatment locally are

to relieve the vascular excitement and tension of the inflamed tissues; to prevent the spread of the disorder to the adjoining tissues which are still free from it; and, when abscesses or mortification of tissue have taken place, to afford such surgical relief as will serve to limit the morbid action within the narrowest bounds, and to prevent the further ill effect which the purulent or other collections are likely to lead to, if they are permitted to remain pent up beneath the fascial coverings. Local applications should be only regarded as subsidiary to the remedies employed in the constitutional and hygienic treatment.

The state of the wound should be first considered. If it be a shell wound with considerable contusion, or a superficial rasing or tunnelled wound by a bullet—the most likely kinds of wounds to be attacked by erysipelas—fomentations or injections of warm water, to which a little Condy's fluid may be added, will soothe the parts, help to remove any foreign or acrid substances or fluids that may be acting as sources of irritation to them, and thus smooth the way towards attaining the effects desired from the remedies which are applied to the adjoining inflamed parts.

To relieve the vascular congestion and tension of the integuments some surgeons employ fomentations, and envelopes of linseed-meal poultices, as applications to the parts involved in the inflammatory action; others resort to depletion by leeches, cupping, repeated punctures, numerous short incisions, or by two or three prolonged incisions, through the inflamed parts. All agree that cold applications are objectionable, on account of their tendency to lower the vital power of resistance in the parts to which they are applied, especially in debilitated patients; and, if they lessen the superficial excitement, to cause the deeper tissues to become involved in the morbid action, or to drive it to some more distant part. I do not think I have ever observed beneficial results from the use of hot fomentations or poulticing the inflamed skin in the early stages of erysipelas. The fomentations do not seem to afford the relief that they often give in simple inflammation, nor are they followed by that relaxation of the vessels or diminution of the tension which might be expected from them. In erysipelas of a phlegmonous character occurring in the extremities, when the action appears to be on the increase and the tension becomes more and more marked, depletion affords the most speedy and surest relief; and the manner of effecting it, which has appeared to me to be attended with the least inconvenience, has been the plan introduced by Hutchison,[50] of repeated longitudinal incisions through the integuments about $1\frac{1}{2}$ inches in length, from 2 to 4 inches apart, and varying in number according to the degree of tenseness of the inflamed parts, and the extent of surface occupied by the disease. Fomentations after the incisions, to promote the escape of a certain amount of blood and serum, add to the local relief and

give ease to the patient. The amount of bleeding which is allowed to take place must be adapted to the patient's general condition of strength. When the bleeding has been controlled, lint wetted with some anodyne lotion, such as the subacetate of lead and opium lotion, is laid over the inflamed part, and the whole is then enveloped in a thick covering of cotton wool, lightly supported by a bandage, and placed in an appropriate position according to the situation of the part concerned. Leeches and cupping are not employed by English surgeons, and scarification by punctures does not seem to be so common as it was in former years.

If there be reason to suppose that the sub-fascial tissues are involved in the morbid action, and, still more so, if there be reason for believing that suppurative action has commenced, the incisions must be deeper. The fascia itself, and the connective tissue beneath, must be freely incised, with a view to afford more complete relief to the local tension, to reduce the pressure caused by the infiltrated and swollen subjacent structures, to relieve pain, to evacuate any purulent collection that may have formed, and to prevent as far as possible sloughing degradation of the connective tissue and gangrene of the surface. Excess of bleeding must be checked by position, the temporary application of hæmostatic substances, with moderate pressure. When the bleeding has subsided, light poultices may be applied, or the wetted lint covered with oiled silk, to soothe and cover the parts. Fomentations and moderate pressure may now be employed with advantage to assist in clearing the purulent collections, or decayed cellular tissue, from the deeper situations. The fomenting fluid may be medicated with some antiseptic substance. The Condy's fluid before mentioned appears to be one of the least irritating, and to be suitable for this purpose. It may frequently be necessary to remove shreds of sloughy areolar tissue by the forceps. Constitutional support, and careful nursing, are in this stage of the disease of vital importance.

Several substances applied to the erysipelatous skin, or to the healthy skin adjoining, have a controlling action on the character of the inflammation, or exert an influence in arresting its onward progress, in the milder forms of the disease. The application of solid nitrate of silver, moistened, to the healthy skin outside the erysipelatous inflammation, so as to form a complete black band around it, will sometimes stop its further spread. Or, if the disease involve the whole circumference of a limb, a similar band may be applied completely around it, above the seat of the erysipelatous inflammation. Care must be taken that the limiting cordon is in each case quite complete. Dr. Chenu mentions that at one of the hospitals at Metz, during the late war, the spread of erysipelas in the extremities was always arrested by the application of a narrow slip of blistering plaister, arranged so as to entirely surround the limb. The blister opposed a barrier which the in-

flammation did not succeed in passing.[51] Blisters have sometimes been applied to the inflamed surface itself, especially in cases in which the inflammation has extended deeply, and in erysipelas of the phlegmonous kind, and have been said to be very useful. They are obviously remedies which must require much caution in their use; for their action, in cases attended with marked debility, might be readily followed by gangrene of the parts to which they had been applied.

Sometimes a strong solution of nitrate of silver, about a drachm to an ounce of distilled water, is applied as a topical remedy over the whole erysipelatous surface and a limited portion of the healthy skin beyond it. The concentrated aqueous solution of perchloride of iron, tincture of iodine, a coating of collodion, have been applied in a similar way, and in some instances appear to have succeeded in putting a check to the disorder. During the United States' civil war some surgeons used a solution of bromine as a topical remedy in erysipelas with, as it was said, very good effects. About half a drachm was mixed with an ounce of water and applied to the erysipelatous surface. But it is only in the milder forms of erysipelas that any reliance can be placed on such means of arresting the progress of the disorder, and only then in conjunction with constitutional treatment and under favourable hygienic circumstances.

Treatment of traumatic delirium after gunshot injuries.—The treatment of this distressing complication of gunshot injuries and of surgical operations following them, is always very difficult, and, unhappily, too often fruitless. Much judgment will be required in the management of cases of this disorder. A correct appreciation of the particular causes which have led to the attack in each instance will give the fairest prospect of a successful issue following upon the treatment adopted.

If the attack be apparently due to the shock of the injury to which the soldier has been subjected, or to the effects of the loss of blood attending it, acting on a constitution which has been undermined by previous habits of intemperance, or by a recent indulgence in alcoholic stimulants, it must be treated on the same principles as an outbreak of delirium tremens. It is in all essential particulars an attack of this disease, brought on by the shock or exhaustion which has resulted from the patient's wound.

The surgeon will probably experience a difficulty in ascertaining the state of the patient's excretions, but it will always be right in the first instance to administer a purgative, taking care that it is not of too depressing a character. Probably the most convenient, and the most efficient in such a case, is to place five grains of calomel on the tongue, giving the patient a little of the stimulant to which he has been accustomed to induce him to swallow it. Twenty-five or thirty drops of laudanum may be added to the

draught to lessen the disturbing action of the calomel, and as a commencement of the sedative treatment which is chiefly indicated. A saline draught, with the addition of sulphuric or some other mineral acid, and a moderate dose of the tincture of opium, may now be given every two or three hours, until the bowels are acted upon, when the saline should be discontinued and the acid and opiate treatment persevered in. If there are difficulties in administering the opiate in draughts, the hypodermic injection of morphia may be used instead. Sleep is the object to be attained, and all that can be done to gain this end, in addition to the exhibition of the medicines just named, should be done. Light should be subdued, and all sources of disturbance, such as noise, bustling movements, and loud talking, be controlled as far as practicable. The action of the opiate should be closely watched, and if, when it has been given in amount up to the limit that would be safe for an adult in an ordinary state of health, it does not appear to be quieting the delirium, or to be inducing sleep, it ought to be discontinued and other remedies tried. Among these may be mentioned the hydrate of chloral, hyoscyamus, and cannabis Indica, as the most efficient substitutes for opium, the first named being the remedy the most to be relied upon. Neither the digitalis, nor the bromide of potassium treatment of delirium tremens, is applicable to cases in which the attack has been induced by the shock or collapse succeeding to a severe gunshot injury.

Important questions arise as to the best mode of maintaining the strength of the patient, and the extent to which stimulants can be given with advantage. It is hardly possible to lay down any precise rules on these subjects; the judgment of the surgeon must arrange them according to the special circumstances of each case under his care. Of the vital necessity for nutrient support there can be no doubt. The disease at the outset is one of debility; it is probable that for some time previously to the attack the digestive organs have been greatly deranged; the wound and loss of blood have lowered still further the vital powers of the patient; the wakefulness, delirious excitement, and muscular exertions of the patient tax them to an inordinate extent; other debilitating influences, if the patient survive, are to be provided for; so that, on all sides, the necessity for nutrient support is urgently indicated. It is useless to try and give nourishment in a solid form, and, even if concentrated in a liquid form, there may be almost insuperable difficulty in getting it swallowed. If the patient will swallow food, the addition of cayenne or other pepper in considerable quantity will help to ensure its digestion. Nourishment is more likely to be taken if combined with stimulants, and probably also more likely to be assimilated; and the tact and thoughtfulness of the medical attendant will be tasked in determining the particular

form in which it will be most acceptable, and the quantities in which it should be allowed. Attempts to administer nourishment by enemata present special difficulties in such cases. The exhibition of stimulants in moderate quantities, especially those which the patient has been accustomed to take, is a necessary proceeding; but this part of the treatment should only be regarded as a means of maintaining the patient until the impediments to the more natural process of replenishing bodily waste, and supporting strength, by food and rest can be obtained. The use of stimulants, therefore, should be gradually lessened in proportion as a return to health shows itself.

If the excessive use of tobacco prior to the gunshot injury be supposed to have influenced the occurrence of nervous delirium, the disorder must be treated on the same principles as when it has arisen from excessive alcoholic stimulation. The best sedative in this case will probably be the tobacco itself, and if the patient is not in a condition to resume its use in the ordinary way, attempts may be made to administer it as an injection. This must be done cautiously, as in this form it will often produce an amount of depression far exceeding its usual effect when smoked.

Whatever the source of the delirious excitement, one of the greatest difficulties met with in the treatment of the patient is that of preventing him from doing harm to himself, either to his person generally or to his wound. A surgeon may be easily thrown off his guard, either by a temporary lull in the patient's excitement, by his manner, or by his remarks. But the subject of this complication must always be constantly and closely watched. His wound, or stump, should be protected in the best manner practicable, but should be exposed to view: for if it be out of sight the patient will not improbably contrive to remove the dressings, splints, or other appliances that may have been employed for its protection. In instances where the excitement prompts the patient to injury of persons near him, or leads to a suicidal tendency, it is rarely safe to trust to the watchfulness and restraint of attendants. The patient must be confined by the straight waistcoat or other similar means. It is a form of restraint that should never be employed when it can be avoided, for it rarely fails to add to the irritation of the patient, and to increased struggling and exertion; but when the patient's own immediate safety, as well as that of his attendants, depend upon unceasing restriction, it is the only means that can be employed with security. Great care must always be taken in employing it, that, while secure, it exerts no local pressure likely to give pain, or impede freedom of circulation.

Some assistance in treating the disorder may be obtained by removing the patient's hair and applying cold lotions to the head. The German head net is one of the best means of retaining wetted

applications to the head under the circumstances of patients in a state of delirium. It is questionable whether any advantage is gained by the application of blisters to the nape of the neck, which are sometimes recommended.

The two important indications of treatment to be borne in mind in all cases, are, first, to lessen, and, if possible, altogether to allay the morbid excitement of the nervous system; and efforts must be made to attain this end through the medium of sleep. If only sleep can be induced, there will be immediate relief of the urgent symptoms; and if it can be maintained to a sufficient amount, a cure of the complication will in all probability be effected. The second important indication is to maintain strength by appropriate nourishment during the attack; and the more prostrated the condition of the patient, whether by loss of blood or any other cause, the more vitally important does this indication become.

A knowledge of the usual causes of the state of nervous irritability which is apt to terminate in traumatic delirium—and they have been already mentioned in describing the complication itself—sufficiently point out the preventive measures to be taken to avert its occurrence. Much may be done towards lessening the nervous irritability consequent on a wound by judicious care and treatment at the first opportunity after its occurrence. Each case will have its own special features, and must be treated accordingly. In some persons moral influence is most required. Kindly and encouraging arguments judiciously enforced will sometimes suffice to allay the nervous irritability in a patient, in whom, under rough usage or simple neglect, and the debilitating effects of his injury, it will go on increasing until it passes the limits of control. In some instances, the prevention of traumatic delirium will depend upon the attention given to the state of collapse into which the injury has thrown the patient; in others, upon the manner in which the patient is supported and raised from the state of general debility into which he has been thrown by the exhausting effects of hæmorrhage. It is especially during the early condition of patients, prostrated by their wounds on the one hand and nervously excited on the other, that careful attention, tact derived from experience, and judicious treatment on the part of the surgeon, are of the highest value, for it is during this period that they can be employed with the most effectual results.

SECTION IX.

ADMINISTRATIVE ARRANGEMENTS FOR THE CARE AND TREATMENT OF WOUNDED SOLDIERS IN TIME OF WAR.

Preliminary remarks.—The nature of the provision which is made for the care and treatment of the wounded men of an army engaged in active military operations, together with the mode of applying these means—whether on the field of action, in the hospitals, or while the wounded are in course of removal from the one to the other—must always have so considerable an influence on the healing and ultimate results of the injuries which they have received, that a description of them could not be omitted from this work without neglecting an important part of the subject of the general treatment of gunshot injuries as they occur in time of war. Whatever amount of knowledge has been gained of the proper course to be pursued in the management of gunshot injuries, it will all be of little avail in practice, especially when this practice has to be conducted on a large scale, if the surgeons have not at their disposal suitable means for the due protection, hospital treatment, and nursing of their patients. The truth of this statement forces itself most strongly upon the attention under the circumstances in which troops are placed during the progress of a campaign. It is one of the functions of the Army Medical Department to consider these subjects, and to make recommendations on them to the War Department of the Government, especially as to the kind and amount of the hospital establishments necessary to be provided for occasions of war; while it is the province of the supreme authorities to determine how far the recommendations shall be complied with. Some of the questions that arise in considering these subjects are by no means easy of solution; so many and so various are the circumstances which exert an influence on the decisions that may be formed regarding them.

On attempting to review the arrangements which are necessary for properly conducting the business of the medical department of an army in time of war, it soon becomes evident that the subject is a very wide and important one. Its extent makes itself ap-

parent when the varied kinds of military operations adopted for purposes of attack and defence are remembered; for, in regard to nearly all these undertakings, forethought has to be devoted, and, in many of them, special provision has to be made, by army medical officers in order that the health of the troops may be preserved, and the sick and wounded duly cared for. Its importance is rendered obvious by studying the histories of campaigns; by observing how much the welfare and confidence of the troops, the maintenance of the strength of armies, and the consequent facilities afforded to commanders for carrying out their strategical designs—not to mention ultimate economy as regards expenditure —have depended upon there being a sufficiency of medical aid, upon the equipment and all essential hospital supplies being adequate in amount and always ready to meet the necessities of the sick and wounded, and upon the plan of hospital administration being well ordered and systematically executed.

The provisional arrangements which particularly influence the results of the treatment of gunshot injuries in time of war, are most conveniently divided for purposes of study into two principal parts; one being that of *organisation and administration*, the other that of *equipment*. Of these two divisions the former is certainly the more important. According to the plan on which the Field Medical Service is organised, and to the intelligence and energy with which it is carried out and adapted to the varying contingencies of war, so will be the degree in which the hospital staff, whatever its numbers, and the equipment whatever its amount, are turned to useful account. When the organisation is good and well administered, the services of all the functionaries included on the establishment will be utilised, and they and the articles of equipment will be in the places where they are most required; when the organisation is bad or badly administered, a vast amount of personal capacity will be wasted, and many things which have been provided will be absent from the places where they are most urgently wanted. Under the first-named condition, when an engagement occurs, the wounded will be regularly attended to, will have their wounds dressed, and will be moved to their appointed hospitals with all the promptitude, regularity, and completeness that the surgeons and means at command render possible; under the second, there will be confusion, needless delay, and, as an inevitable consequence, a great increase to the amount of suffering, prolonged hospital habitation and treatment, and, ultimately, an aggravation of the ratios of invaliding and mortality among the patients. Even though the hospital staff may be comparatively limited in number, and the supply of transport and other hospital equipment only moderate in amount, yet, if well organised and handled, they may enable the requirements of the wounded to be more quickly and efficiently attended to, than a far

more numerous staff, and more abundant stores and transport, under contrary conditions. Substitutes, more or less perfect, can be found for many authorised articles of equipment, while extra zeal and devotion may make up for deficiencies in the numbers of the medical or subordinate staff; but nothing can prevent the evils which follow in the wake of imperfect organisation and careless administration. The quality of the administrative arrangements of the medical department of an army is quite as important, indeed, under some circumstances, even more so, than the quality of the executive medical service at command. The amount of professional knowledge of the medical officers, and of their practical expertness in performing surgical operations, will doubtless determine the results of the treatment of many individual wounds and injuries; but it must depend upon the general administration how quickly, and under what conditions, this knowledge can be applied. Thus, though the surgeons may possess all the knowledge and experience which are requisite to enable them to decide exactly what should be done in each particular wound and injury that may fall under their care, and though they may have acquired the skill and adroitness of a Fergusson or a Paget as operators, yet all this science and ability may be rendered comparatively fruitless, so far as the wounded are concerned, by an inappropriate system of administration. These are some of the reasons which have led to army medical officers being employed in two capacities, administrative and executive; for, to superintend the proceedings necessary for carrying a predetermined plan of dealing with the wounded of an army into effect, to settle the various questions and to remove the difficulties which may arise out of these proceedings during their progress, and to take the necessary steps to ensure that all the parts of the system shall work regularly and smoothly in concert, requires much previous study and acquaintance with military organisation, particular tact and energy, and an amount of supervision which can only be given by an almost exclusive devotion of time and attention to the duty.

A description of the arrangements which are necessary for preserving the general health of troops in the field, and of the steps to be taken for their practical execution, although they indirectly influence the effects of injuries when they occur, does not belong to this work: they are treated upon in books on army hygiéne. Only those matters can be noticed which have a special bearing on the wants of *wounded* men. These will be considered under the four following heads, viz.: (1.) Hospital organisation; (2.) Hospital administration; (3.) Hospital equipment; and (4.) Sick-transport equipment.

CHAPTER I.

ARMY HOSPITAL ORGANISATION.

Organisation of the army medical service in peace relatively to time of war.—As an army is only maintained for purposes of war, it is obvious that the organisation of its several parts in time of peace should accord as far as practicable with the organisation which will be necessary when war occurs. This applies to the Army Medical Department equally with all other parts of the army. The constitution of the hospital staff, both medical and subordinate; the direction and distribution of the functions belonging to its several parts; the system on which the hospital duties are conducted; the transport arrangements; the forms of the transport vehicles and of the hospital equipment, should all have reference to the necessities of time of war. The staff will thus be trained and accustomed to the duties which they will have to perform in the course of a campaign, often under very difficult circumstances; and they will become familiar with the equipment which will be placed at their disposal for use in the field. Many improvements will suggest themselves from the experience which may be thus gained; and, in the end, the various demands which are made on the medical service with such special urgency in time of war will be more easily, more systematically, and more successfully answered.

But though the general principles on which the constitution and mode of action of the Army Medical Service are based, may be alike for peace and war; and though unity of pattern may be attained in most of the instruments and articles of equipment in daily use by the officers of the department; such complete and perfect accord as may be attained in the organisation, exercises, equipment, and many of the administrative arrangements of the combatant parts of an army, cannot be accomplished in the medical branch. The circumstances of peace and war differ too greatly to admit of all the same details of hospital administration and duties being employed in the two conditions of service. In time of peace, the wants of the sick and hurt of an army can be more economically, and more satisfactorily, attended to in permanent hospitals furnished with standing equipment. In time of war, when once troops have taken the field, such fixed establishments are only available under very exceptional circumstances. It is uncertain where battles, entailing the necessity for surgical attendance on an enormous scale may be fought, and, independently of these great occasional demands, there is a constant need of medical or surgical help on the line of march, in the bivouac, and, indeed, in all situations where soldiers may be placed during

a campaign. These numerous wants must be considered and provided for before the troops start on their expedition. They must be met when they occur by means of establishments which move along with the army, and by an action on the part of the surgical staff which must be specially adapted to the particular circumstances under which the several demands arise. As it is with the purpose of fighting battles that armies are usually set in motion; as it is on the occurrence of general actions that the numbers of wounded assume the most considerable, sometimes, indeed, almost overwhelming, proportions; and as these are the occasions on which the resources and energies of the surgeons are most severely tried; it naturally follows that the needs of battle are especially kept in view, when the organisation and equipment of the surgical department of an army are being considered. All other surgical arrangements in campaigning must be subordinate to those necessary for supplying the great and trying needs which arise on the day of battle.

Needs of wounded soldiers when a battle is fought.—It will be useful to consider briefly what are the surgical necessities of men wounded in a great battle. A review of the requirements which have to be met, will render the study of the best means of meeting them all the easier.

Some men wounded in action will be able to make their way unassisted to a place of shelter and help; but many others, from the nature of their wounds, will be deprived of this power. These latter, if they are to be moved away at all, must be carried to a place of shelter. The wounds of all will require some surgical attention. In certain instances the performance of early operations will be essential for saving life; in many others, the application of such supports as will protect the wounded parts from increased injury, during the removal of the patients further to the rear of the scene of action, will be of vital importance. After receiving such preliminary care, the wounded will require to be removed to certain hospitals for definite treatment. The condition in which many of the wounded will be, renders it desirable that these hospitals should be as little remote from the scene of conflict as practicable. The time during which the patients will remain in the field-hospitals where they are first received, must vary with many circumstances. The nature and gravity of the wounds, the amount of accommodation available, the opportunities of transport, the situation of the hospitals, the course of the military operations and movements, the system adopted in regard to removal and dissemination of patients, and many other such matters, will influence the duration of their stay in them. It may happen that the patients will be retained in the field-hospitals only a few hours and then be sent on to other hospitals more in the rear, or they may remain in them for a few days, or even several weeks, before removal. If the field-

hospitals are established in villages or towns, the period of their stay in these places may be prolonged until they have become convalescent. From these hospitals they will either be discharged to return to their duties in the ranks, or they will be sent to a general hospital at the base of the military operations, from which those among them who have become disabled by their wounds will be sent away as *invalids* to their native country. They will then be finally disposed of according to the nature of their injuries, and the results which have followed them.

Subdivisions of the subject of army hospital organisation.—In studying the plans best suited to meet the necessities of the wounded which have just been described, it will be convenient to subdivide the subject under the following heads:—(A.) The Personal Staff necessary and its organisation; (B.) The Ambulance and Hospital Establishments necessary and their organisation; and these will be treated upon in the present chapter.

A. The Personal Staff necessary and its Organisation.

The personal staff that is required to ensure proper care of the wounded in time of war, with due regard to their necessities already enumerated, consists of several distinct sections. When classified according to the nature of the duties which have to be performed by them, they are:—1. *The bearer personnel;* 2. *the surgical personnel;* 3. *the personnel of the movable field-hospitals;* 4. *the personnel for preserving order;* 5. *the train personnel;* 6. *servants to officers;* 7. *the personnel of the intermediate field-hospitals; and* 8. *the personnel of the general hospital at the base of operations.*

In remarking upon these divisions of the personnel, I propose to describe almost exclusively the arrangements regarding them that are ordered in the British service by existing regulations.

1. **The bearer personnel.**—The staff told off for picking up and removing wounded soldiers from fields of battle, stand first in the list, as their duties are the first to be performed in helping the wounded. The need for a special personnel of this denomination will be apparent on slight reflection.

It is obvious that those officers and soldiers who are so severely wounded during a battle as to be unable to make their own way out of the conflict, must either be left where they have happened to fall until the fighting ceases, and be exposed to the risks of additional wounds from the fire of the troops opposed to them, as well as to injuries from the horses, guns, and troops moving in their vicinity; or they must be removed to the rear by some of their comrades, or by men specially provided for the purpose.

All must desire that men wounded in the manner described, and, therefore, deprived of the power of defence as well as of offence,

should not be subjected to the mental torture, increased bodily suffering, and serious risks, inseparable from the first-named alternative. The evils of the second alternative have been long known The number of fighting men abstracted from the ranks when wounded men are carried off by their comrades, the difficulties of getting many of them to return after the mission they have undertaken has been completed, the disorder and confusion created by the proceeding, have been often described, and need not be dwelt upon here.

Defective arrangements hitherto in the British army.—The powerful objections against wounded men being left altogether uncared for, and also against their removal from the field by comrades, have led, for many years past, to special arrangements being made in all the Chief continental armies for meeting this particular want. There has always been an acknowledged deficiency in this respect in the arrangements of the British military service. Indeed, the only men hitherto regarded as available for the duties of bearers of wounded in the British service have been the bandsmen of regiments. But the dependence on bandsmen has never been a real one. No distinct regulations were ever promulgated on the subject; nor has any system ever existed for educating bandsmen for the performance of the difficult and responsible duties which would devolve upon them, if they were called upon to act as bearers of wounded. Their education and duties as musicians are of a very special character, altogether foreign to those of sick-bearers. It is obvious to everyone who is acquainted with the nature of the duties which bearers are called upon to perform, that no system of collecting and bearing the wounded off a field of action can be complete, which does not comprehend both theoretical and practical instruction. Constant confusion and suffering must result in the absence of special education on such duties. Moreover, the instruction, once imparted, must be maintained by periodical exercises at certain intervals of time, or the acquired dexterity will soon be lost. The art of removing wounded men and attending to the first necessities of their condition, without aggravating their sufferings and adding to the gravity of their wounds, is a very difficult one. To practise it properly, a certain amount of special knowledge and manipulative expertness must be acquired, as well as habits of discipline and obedience; and, to impart this knowledge and expertness to soldiers, a thoroughly organised establishment is as necessary as one to teach them the use of a rifle or any other technical operation. It is a duty, too, which is only fit to be entrusted to men who show that they possess the necessary physical qualifications, together with some amount of tact and gentleness of character. To make a proper selection of bearers of wounded is a task which requires both experience and skilled observation.

Difficulties in organising a personnel for removal of wounded.—While mentioning that the removal from the field of battle to the field-hospitals has always been the most neglected part of the system on which help has been planned to be afforded to wounded soldiers in the British service, and the most defective in practice, it should at the same time be stated that it is probably the most difficult part to arrange satisfactorily from an economical point of view. The difficulty is to organise a system for meeting a want, which is only a very occasional one, in such a way that the men prepared to supply it may be advantageously employed at other times, when that particular need does not exist. It is true that the necessity which combatants are organised to meet—fighting—is also only an occasional one; but the general safety has been well understood to depend in a great degree on having men trained and prepared to meet this want at all times, while the necessity for having men trained and ready for the removal of those who may fall wounded has been hardly considered. So also guns, and other implements of warfare, are only employed in the work they are specially contrived for at rare intervals, and it is certain that, whenever they are so employed, the need for the removal and care of wounded will simultaneously occur; but here again, while the importance of studious prevision and preparation in every minute detail of the means of inflicting wounds is practically acknowledged in every army, the need for similarly careful preparation in the arrangements for meeting the surgical necessities entailed by them is admitted but by few, and even by them has hitherto been ignored to a very great extent in practice.

In countries where conscription is in force, the system of having corps expressly organised and drilled for the removal and transport of wounded men can be carried out without much difficulty, and there can be no well-grounded excuse for its neglect. All who are liable to conscription have a personal interest in the system of help in the field being complete; and there is not the same paucity of men, or costliness in maintaining them, as there must be in a country whose army is constituted on the principles of enlistment. It is easy, in such countries, to keep a reserve of men trained in the special duties of bearers, to renew the training from time to time at suitable periods, and, when the forces of the state are mobilised on the occasion of war, then to call them into the ranks for service.

There is now happily good reason for hoping that the defects which have just been mentioned will not exist in future in case of British troops being engaged in war. A complete system has recently been organised under the presidency of Sir William Muir, the Director-General of the Army Medical Department, for removing and aiding the wounded arising from battles. This system having received the sanction of the Government and Commander-in-Chief,

has recently been promulgated in army orders.[1] It is the first time that any plan of the kind has been adopted in the British service; and it is scarcely possible to speak too highly of the advantages that will accrue to the wounded on the occasion of sharp engagements, and, still more so, of great battles, should the system be efficiently carried into execution.

Arrangements of 1875 for the removal and care of wounded in the field.—In August 1875, certain tables were issued by the War Department showing the war strength and composition of the several parts of an army corps; and in them were shown a certain number of 'ambulances' and 'sanitary detachments,' in addition to the field-hospitals, as establishments of the Medical Department.[2] Each brigade 'ambulance' in the scheme comprised 4 medical officers, 17 army hospital corps men, 17 drivers, and 17 ambulance wagons. There were also divisional and corps ambulances. The 'sanitary detachments' with the army corps comprised 12 medical officers, 6 other officers, and 1,000 men of the Army Hospital Corps. Further details of these establishments were not given. It seems evident, from their composition, that the ambulances and sanitary detachments together were intended for the service of removing the wounded from the fighting line to the line of the field-hospitals; but the system on which the service was to be conducted was not promulgated, and the matériel, appropriated to the ambulances and sanitary detachments, did not comprehend many things that are essentially necessary for meeting the wants which arise on the occasions of large battles. Moreover, it has been shown to be utterly impracticable to maintain the Army Hospital Corps at such a strength as would enable it to provide 2,200 of them for the duties of the field-hospitals and sanitary detachments—the number estimated for the service of one Army Corps in the tables above-named.[3]

New arrangements for the removal and care of wounded in the field.—The plan which has now been adopted comprehends three distinct categories of personnel for ministering to the necessities of the wounded on fields of action: 1. A regimental staff; 2. Special companies for performing the duties of bearers and of the dressing-stations; and 3. The personnel of the field-hospitals. This field establishment is supplemented by additional personnel for the intermediate field-hospitals to be stationed along the line of communications between the active army and its base of operations, as well as for the general hospitals formed at the base itself. It is intended by this division, not only that the respective personnel shall be charged with special duties and responsibilities, but that it shall also be capable of adapting itself readily to any need for assistance according to its extent and gravity. When an engagement is a slight one, or in the early period of a grave battle, the regimental personnel will probably suffice for the first wants of

the wounded, and their removal to a place of shelter. When the engagement is one of more importance, and when the number of wounded becomes greater than the regimental personnel is adequate to deal with, the bearer company will be available for meeting the increased demands for transport and professional assistance. On a field-hospital being opened, the system of help, so far as concerns the personnel on the field of action, will be rendered complete. The personnel of the intermediate and base hospitals will be subsidiary to that with the army in the field.

Regimental bearers.—The regimental bearers can only be obtained from the ranks of the regiment. If two men of each regimental company are available for the purpose, they will be able to meet the first wants, as regards removal of wounded men, at the commencement of an engagement, or when part of a regiment is detached on outpost or other duties. Regimental stretchers are supplied for the purpose, and are carried on the company carts. These soldiers would only be employed in the duties of bearers on being ordered by the officer commanding the regiment or detachment to do so; and, when so employed, would receive directions in respect to the wounded from the medical officer with the troops.

The employment of two regimental bearers from each company will only diminish the fighting strength to a small extent; and, on the other hand, ought to be the means of obviating the evil of other soldiers leaving the ranks to assist the wounded. There will be less excuse for men engaging as volunteers in such a task when there are regimental bearers who are prepared for it, and whose fixed province it is to perform it. Indeed, as General Sir William Codrington has observed, the only way of preventing the tendency to help wounded comrades off the field is to have men whose special function it is to help them. When this is done, it becomes a breach of duty for any other person to leave the ranks.[4] The training of the regimental bearers need not go beyond the proper modes of removing wounded men on stretchers, and giving the simplest kinds of first assistance to them. It need not take more than three or four weeks at the furthest for its acquirement. Four men should be trained in each company, so that two may always be ready for the duty. At the same time it will be necessary for the regimental bearers to be exercised at some regular periods with the 'Bearer Companies,' upon whom the service of removing the wounded will mainly depend, in the same manner as military manœuvres are practised by the combatant troops. While wearing the uniform of their regiments, they should be distinguished from the rest of the men of the regiment by some distinguishing mark. During the Franco-German War, the auxiliary regimental bearers in the German armies wore a white brassard with a red cross upon it on their left arm; but this was considered objectionable, and a red arm badge has since been substituted for it.[5]

The bearers of the bearer company.—A bearer company will principally consist of a corps of stretcher-carriers attached to each division of an army; being organised for the express duty of gathering the wounded, giving them first attention, and carrying them to the ambulance wagons for removal to the dressing stations and to the field-hospitals. As the bearer company also comprises a staff of medical officers, officers of orderlies, the personnel for conducting the transport of the wounded by the wheeled vehicles, with the men of the hospital corps for the subordinate duties of the dressing stations, it has a complex constitution. Its composition will be shown in full farther on.

The bearers in a company are 95 in number, and are only added to it on its being completed for active service in the field. In time of peace they are to be retained in the 1st Class Army Reserve. It has been suggested that a proportion of the Army Hospital Corps should be only enlisted for such a time as will enable the men to be properly instructed in the duties of bearers, and that, when this instruction has been completed, they should be passed for the remainder of their engagement into the reserve force just named. After a time the Army Hospital Corps will then consist of two separate classes. One class will be that of skilled hospital attendants, and will be retained for duty in the hospitals; the other class will be that of stretcher-carriers, and will be retained in the reserve, ready to supplement the corps for field service on occasion of war. Should need arise, before a sufficient number of bearers have been trained to subsidise the Army Hospital Corps in the manner described, they might probably be obtained from the Militia Reserve.

The training of the bearers, judging from what is done in Germany, will not occupy more than a month. In this period men of ordinary intelligence will be competent to act as stretcher-carriers, and to work with wheeled and other sick-transport conveyances; to apply, in the absence of a surgeon, such primary apparatus as may be of advantage to the wounded; to learn to distinguish between living and dead lying on the field; and also to discharge the military duties of guarding stores and conveyances, and performing fatigues and other such services as are usually required in the field. They will have to be exercised in them occasionally that they may keep up the acquired training. The duties of bearers require them to expose themselves freely to fire while the action lasts; the weight to be carried by them and the ground to be passed over are considerable; the position of the load irksome; and, therefore, in addition to the necessary training and manual skill, it is evident that coolness, courage, and strength are also important qualities for such men to possess.

2. **The surgical personnel in general.**—The duties and responsibilities assigned to the different sections, and grades, into which the surgical personnel is divided, vary in different armies. The

following is a general survey of the constitution of the personnel of the medical department in the British service.

The department is subdivided into several special branches. It consists of (*a*) the medical officers; (*b*) the army hospital corps. The regulations also provide for an establishment of female nurses to be employed in general hospitals. There was till lately another branch, the purveyor's branch. The duties of the personnel of this last branch consisted in providing the necessary hospital stores and equipments, the dietary, in issuing hospital clothing, and providing for all the personal wants of the patients, in keeping the returns of supply and account, and other such duties. This branch is now transferred to the Commissariat Department of the army.

Medical officers.—The medical officers are divided into two classes of officers: the *executive* and the *administrative*, each set having distinct duties.

The executive division has two grades, viz., surgeons and surgeons-major. The administrative division has also two grades, deputy-surgeons-general and surgeons-general. They act immediately under a director-general, who is the responsible administrative head of the whole department.

The duties of the executive medical officers are to perform all hygienic, medical, and surgical duties that may be required in the army under whatever circumstances the troops may be placed; to collect and tabulate meteorological observations wherever the troops may be quartered; and to keep up the statistical and professional records. The nature of these duties in detail, and the forms under which the records are to be kept, are described in the general code of 'Army Medical Regulations.'

The duties of the administrative officers consist in making visits of inspection; in ascertaining that the sanitary and medical regulations of the army are duly observed; that the professional records are properly kept; in advising with executive officers on measures for the mitigation and prevention of disease; in seeing that the state of the hospitals, the supplies, the arrangements for the care and treatment of the sick, are good and efficient; and, further, in time of war in indicating and superintending, as far as practicable, the arrangements made for the care, treatment, and distribution of the wounded. The medical officers of the British army have never been invested with any power of independent action in the direction of hospitals; nor, strangely enough, have they ever had any disciplinary authority or command over the subordinates who are placed to do duty under their direction in the hospitals; but it is understood that changes are about to be made in these respects.

The army medical officers require various qualifications to enable them to discharge their functions in a satisfactory way. The executive medical officers should be prepared to practise all branches of medicine and surgery. The special divisions of surgical and

medical science, and the particular applications to certain subjects, to which practitioners in civil life devote themselves, are altogether inadmissible in military practice. The army surgeon must comprehend in his range the whole sphere of professional science and practice. He must, in addition, possess a variety of other knowledge, peculiar to army practice, in order to be a thoroughly efficient officer. He ought to be acquainted with the science and application of hygiène as regards bodies of men in all climates; the preparation of various technical returns and reports; and the nature and uses of all the articles comprised under the general terms of field medical, surgical, and transport equipment. The army regulations bearing upon the management of patients in general hospitals and on field service, and those upon his own relations to other officers and other departments of the military service, should be all familiar to him. Certain physical qualifications are also of essential importance to the army surgeon. He should have a healthy and robust constitution, in order to resist successfully the exposure and various trying circumstances incidental to military life in general, and especially to campaigning. Moral qualities, to ensure him due respect from those with whom he is associated, and to procure the esteem and confidence of the troops placed in his charge, should also not be wanting.

The administrative medical officers should have passed through the grades of executive officers, and should have proved their superiority by the possession of special scientific, moral, and physical qualifications while in those grades. In addition, the officers selected for administrative appointments, should have shown themselves prudent, sagacious, capable of dealing with sudden emergencies promptly, and thoroughly imbued with habits of military discipline. It is equally true of medical as of combatant officers —those who have conducted themselves best in subordinate positions will almost always conduct themselves best also when placed in superior positions. Circumspection; the ability and decision of character which will impress the higher military authorities with respect for opinions and advice; the administrative tact, in addition, which will procure willing obedience and excite professional zeal among the executive officers and departmental functionaries under their administration; these are the qualities which will mark the most successful administrative officers of the army medical service.

All medical officers, executive and administrative, should be able to ride. Inability to ride well will frequently prevent them from being of use on field service, on occasions when their services might be of essential importance. As the majority of the candidates for commissions in the Army Medical Service have not had any previous opportunity of accustoming themselves to horse-riding, it has been a subject of regret that arrangements have not been made

for enabling them to go through a certain amount of riding drill at first starting upon their military career. Steps are being taken, it is understood, to supply this defect in future. It is especially important that all the medical officers belonging to the bearer companies should be mounted. This arises from the necessity that exists for them to keep up constantly with the troops of all arms, in order to be able to attend to men requiring their aid: for their frequently having to move to and fro rapidly while engaged in their special duties; and for their being spared avoidable fatigue, in order that they may be able to devote full energy to the important work which devolves on them, often at the close of the day when other officers are free to obtain repose.

Consulting surgeons and special operating surgeons.—Certain specially functioned medical officers are comprehended in the surgical arrangements for time of war in some armies, in addition to the personnel above described. Such are consulting surgeons and operating surgeons.

Of late years in the North German army, on the occurrence of war, the most eminent hospital surgeons in civil practice have joined the army as consulting surgeons. One such consulting surgeon, with the rank of surgeon-general, was attached to each German corps d'armée, during the late Franco-German war. There are undoubted advantages in having for an army the help of surgeons who, in consequence of their distinguished scientific attainments, vast experience, and known skill, are acknowledged to be the highest authorities in the surgical profession; but the arrangement is one which must be conducted with special tact and discretion for it to work smoothly in practice.

A peculiar feature of the field-hospital organisation, during the War of the Rebellion in the United States, was the appointment of certain medical officers and assistants, without regard to rank, for the special duty of performing the surgical operations required during and after an action. It was the duty of the surgeon-in-chief of each Division, acting under the orders of the Medical Director of the Army Corps to which the division belonged, to select the operating surgeons, choosing them for their known skill and judgment as operators. This, no doubt, arose from the hurried circumstances under which the American armies were at first organised; so that it was impossible to avoid the admission of some surgeons without the necessary experience and dexterity in operating, the possession of which is of such extreme importance as regards not only the limbs, but frequently the lives, of those who have to undergo surgical treatment on a field of battle. There can be no doubt that known adepts as operating surgeons ought always to be placed in positions where their superior skill can be best turned to account. But the competitive ordeal in London, in the first instance, and the subsequent special training which the surgeons of the British army pass through before they are admitted into its ranks, ought to render

any restriction in respect to the performance of surgical operations unnecessary under ordinary circumstances, for all start alike with the requisite knowledge imparted to them. It is expected that the knowledge which they have gained of operative surgery at starting, and, therefore, the consciousness of the importance of its possession, will cause all military surgeons to maintain and increase it by study, and by taking advantage of every opportunity that occurs for manual practice afterwards. If any fail to keep up their information and to add to their experience in this way, they must inevitably fall back in surgical knowledge, and lose the manual dexterity they may have previously acquired, for of all technical skill that of the surgeon slips away most readily without practice; and in such cases, on the occurrence of an action, it would be the duty of the administrative officers in charge, in the interest of patients, to restrict the officers devoid of skill from acting as operators, and to direct others to take their places. Mistakes in the use of the knife rarely admit of remedy.

The army hospital corps.—This corps has been organised for duties in connection with the hospital service of the army, and is an integral part of the Army Medical Department. It has hitherto only been subject to the orders of the local military authority in matters of discipline; but, in other respects, has been under the direction of the principal medical officer of the station where it is quartered. Its officers are styled Captains and Lieutenants of Orderlies. They are the adjutants, paymasters, and quartermasters of the corps. The corps furnishes all the subordinate hospital staff for the fixed and field-hospitals of the British army. Non-commissioned officers of the corps, after becoming duly qualified, are now entrusted with the duties which were formerly discharged by the apothecaries' branch of the army. They are made responsible for the care of all the medicines, surgical instruments and appliances, in the army medical stores and elsewhere; and they perform the important duties of dispensers and compounders of the prescriptions of the medical officers. The personnel of this corps are also directly entrusted with the nursing and attendance upon the sick and wounded by day and night; with maintenance of cleanliness in and about the wards; with charge of the kits and all other property of the sick admitted into hospital; with the cooking and distribution of diets; and all other details of interior hospital economy. They have the care of all buildings, grounds, and enclosures while in hospital use, acting under the general directions of the principal medical officer. They are required to pitch, strike, and pack with celerity the hospital marquees and tents; to be familiar with the manipulation and preservation in good order of all articles of field-hospital equipment; and with all other ambulance duties. They also have the necessary training to fit them for acting as bearers of wounded, in case of need, and as guards over them during transport in wheeled and other conveyances.[6]

3. Field-hospital personnel.—Former regulations admitted only two distinctions of personnel—regimental medical officers, and staff medical officers; the former for duty in regimental hospitals, the latter for duty in general hospitals, wherever established. Brigade and divisional hospitals were occasionally formed in the field, as they were during the Crimean War in the standing camps before Sebastopol. When constituted, the necessary surgeons were collected from various quarters, and they varied in numbers according to the size of the hospital and exigencies of the service.

After the Crimean War, when the field equipment of regimental hospitals was much increased, and large supplies of reserve stores were added for brigade and divisional field-hospitals, the new arrangements did not include any fixed description or amount of personnel for these last-named establishments. They were left to be organised and supplied according to local circumstances. These incomplete arrangements have now been abandoned, and special field-hospital establishments have been introduced instead.

Recent constitution of field-hospitals.—In future the field-hospitals of the British service will be constituted with a definite personnel and fixed establishment, on a plan very similar to that which has answered so well in the German service. The special purposes and advantages of the system will be explained hereafter. It will be sufficient in this place to mention the numbers and functions of the personnel belonging to one of the new field-hospitals.

Each field-hospital is formed to accommodate 200 patients, and is divisible into two half field-hospitals. The following table shows the composition of the personnel, with the amount of transport assigned to the hospital.

PERSONNEL.		
Surgeon-Major in charge	1	
Surgeons-Major	2	
Surgeons	4	
Captain of orderlies	1	
Officers		8
Sergeant-Major (steward)	1	
Col.-Sergt. (assistant steward)	1	
,, (ward masters)	2	
,, (compounder in charge)	1	
Sergeant (compounder)	1	
,, (storekeepers)	2	
,, (P.M.O.'s clerk)	1	
,, (cooks)	2	
2nd Corporals	4	
Privts. (4 assistant cooks included)	22	
Army Hospital Corps		37
Drivers, Army Service Corps	22	
Bâtmen, &c., Militia Reserve	8	
		30
Total personnel		75

TRANSPORT.	
General service wagons for tentage and equipment	4
Ditto for hospital equipment	4
Pharmacy wagons	2
Water carts	2
Vehicles	12
HORSES.	
Riding	8
Draught	44
Total horses	52
TENTS.	
For officers (circular, single)	2
For N.C. officers and men (ditto)	6
For patients (double circular bell tents)	50
Operating tents (double circular without lining)	2
Total	60

The officers, non-commissioned officers, and men of the Army Medical Department form the cadre kept up in time of peace: the drivers and bâtmen will only be included when their services become necessary for active operations in time of war. An officer and some non-commissioned officers of transport will also be added, on taking the field, to superintend the transport arrangements.

4. **Personnel for preserving order.**—Many irregularities are liable to occur in the immediate rear of troops engaged in a general action, under the excitement and distraction of battle. They do not result so much from acts of the troops themselves, as of camp followers, hired or requisitioned transport drivers, and other inhabitants of the country in which the war is being carried on. It requires special provision to control these irregularities. Those who are charged with the ordinary military discipline of the personnel of the bearer, train, and field-hospital establishments have other duties to engage their attention on such occasions. No arrangement has been made in the British service for a special ambulance police, as in some other armies; but, as a troop of military police is to be attached to each division of an army corps by recent regulations, there can be no doubt but that one special duty of these mounted men will be to preserve order in rear of the troops engaged with the enemy. They may also do essential service in assisting to prevent interruptions to the movement of the wounded to the dressing stations and field-hospitals.

5. **The train personnel.**—The subject of the 'Train Personnel' is intimately connected with that of the 'Bearer Personnel,' which has been already discussed. The distinguished officers who were appointed in 1866 to inquire into the administration of the transport and supply departments of the army, recommended in their report that an 'ambulance train,' formed of picked and specially trained drivers and officers, should be organised: that there should be kept up a peace establishment of ambulance vehicles, mules for litters, &c.; that the conductors of these vehicles and animals should at certain periods be attached to and do duty with the army hospital corps; and that the men of the ambulance train should have the arm brassard of the Geneva Convention on their uniform. The committee reported that 'the arrangements for removing wounded soldiers out of action, and for the transport duties connected with the hospitals, are, in the opinion of the committee, in a very undefined and unsatisfactory state as regards both the responsibility for, and the means and appliances of, the service. The evidence shows how ill understood and how imperfectly provided for by regulation are the relative responsibilities of officers regarding transport of sick and wounded.' Much of this uncertainty will be removed by the recent changes in organisation. The formation of an ambulance train, however, as recommended by this committee, has not been carried out.

The duties of removing the sick and wounded by wheeled and other transport conveyances are entrusted to the transport branch of the Commissariat Department, without particular selection. It would be better for the sick and wounded—considering the peculiar nature of the service—that a special training should be given to certain selected transport officers and drivers of the army service corps in ambulance transport, and that they should be familiarised in co-operating with the bearers and hospital attendants, as the committee recommended. Even the mere driving of carriages, containing badly wounded or very feeble men, requires more method and consideration of a special kind, than are likely to be given to the subject by men who have not been instructed in it, and whose usual charge consists of inert stores. The 'Autumn manœuvres' offer a proper opportunity for practising an 'ambulance train.' Corresponding establishments always act with the troops at the Autumn manœuvres of Continental armies.

6. Servants to officers.—A necessary part of the personnel of all hospital establishments in the field are servants for the medical and other officers belonging to them. If they are not provided, the officers will have to devote part of the time to their own concerns, which, otherwise, would be given to those of the patients. It has been the custom in the British service, as regards army surgeons on general duty, to trust to the hire of private servants. This system answers sufficiently well in time of peace; but, not to speak of the military objections to civilians moving to and fro in the ranks of an army, it is very difficult to obtain them under any circumstances in time of war, and often, when obtained, they cannot be induced to stay. They will not submit to the exposure and privations inseparable from campaigning; and these are all the more felt by them, because they want many of the privileges and advantages which soldiers, and other military subordinates, possess in the field. During the Crimean War it not unfrequently happened that the staff surgeons had to clean their own boots and appointments, and to procure and prepare their own meals. This could not be done without the interests of the sick and wounded suffering. In most Continental field-hospital arrangements the personnel includes military servants for the officers, distinct from the attendants on the sick; but, in one or two foreign armies, it has hitherto been the custom for some of the infirmiers, or hospital orderlies, to be assigned as servants to the medical officers. This is an objectionable proceeding. Army hospital corps men ought never to be employed in such service. They are trained and paid for other more important duties, and their time and services should never be diverted from their legitimate functions. It will rarely occur that they are not wholly required by the sick.[7] Such irregularities are now provided against in the new arrangements. The bâtmen, who form part of the personnel of the bearer companies and field-hospitals, ought to prevent any occasion for

hospital attendants being diverted from their proper duties to act as servants to the medical officers of these establishments.

7. **Personnel of the intermediate hospitals.**—By the recent arrangements 25 field-hospitals are appropriated to an army corps. Of this number 12 are to be with the troops in the field, and the remaining 13 are to be stationed along the line of communication in rear of the army, or at the base of operations. The personnel of each of these 13 intermediate and base hospitals is similar in composition and number to that of the movable field-hospital before described.

Personnel of the general hospital at the base of operations.—The regulations of 1859 ordered that general hospitals were to be organised under the following officers:—1. Governor or commandant; 2. Principal medical officer; 3. Apothecary; 4. Purveyor or steward; 5. Paymaster; 6. Captain of orderlies; 7. Superintendent of nurses, when nurses are employed.

The change in the military arrangements for maintaining the communications between the base and the army operating in the field, has rendered a change in the organisation of the medical staff necessary. The general officer commanding at the base of operations, and responsible for the communications with the army, will require a surgeon-general as principal medical officer to advise with on the distribution of the sick and wounded along the route from the army to the base, and on the disposal of those collected at the base. The surgeon-general will require the services of administrative officers for the sanitary duties, and to represent him in the general direction of the intermediate hospital establishments, and of the movements of patients, along the line of communications with the army in the field. As the surgeon-general at the base, although acting independently of the surgeon-general with the army in the field in most of his functions, must be responsible for there being a sufficiency of hospital stores and equipment at the base to meet the wants of the field-hospitals, he will require a reliable medical officer to keep him informed on all details connected with this part of his charge. The constitution of the administrative surgical staff for the general hospital at the base, and for the administrative duties between the base and the active portion of the army, will, therefore, probably be as follows:—

Surgical staff	Rank	No.
Principal Medical Officer . . .	Surgeon-General . .	1
Line Inspector	Deputy Surgeon-General	1
Sanitary Inspector	Deputy Surgeon General	1
Secretary to Principal Medical Officer	Surgeon-Major . .	1
In medical charge of staff at base .	Surgeon-Major . .	1
In charge of surgical and medical stores	Surgeon-Major . .	1

Selection and distribution of the surgical personnel.—Having now described the principal classes of the personal staff which are necessary for conducting the duties connected with the transport, care, and treatment of wounded men in the field, it may be useful to indicate the manner in which the medical personnel is generally distributed. The following have been the usual arrangements. The Director General under authority of the Minister for War, nominates the principal medical officer of the army taking the field, and provides and despatches the number of surgeons of all ranks destined for the campaign. In the field, the principal medical officer receives his orders from the general commanding, or the chief of his staff. All the field medical service is under his direction. The distribution of the medical officers sent out by the Director General has hitherto been settled locally by the principal medical officer of the army, while the force has been assembling at the place of rendezvous. With the sanction of the general officer in command, and acting in concert with the heads of other departments, he has allotted the medical officers to their several stations and duties:—some to the chief general hospital, and any other stationary hospitals, that may be formed at the base of operations; some retained for duty in the intermediate hospitals which may afterwards have to be established, and to replace casualties in the field; some for charge of the field-hospitals and duty in them; and others for charge and duty with the ambulance transport. The regimental surgeons have remained with the regiments to which they had been previously attached.

Now that particular knowledge and special qualities will be essential for properly conducting the duties of certain charges, such as that of a bearer company, or a movable field-hospital, it is probable that some of the personal arrangements, hitherto made by the surgeon-in-chief on the spot, will in future be made by the Director General before the force leaves England. He alone, on the first starting of an expedition, can have sufficient acquaintance with the capacities and qualities of the surgeons sent with it, to enable a right selection of them to be made for posts of particular trust.

The grades and strength of the surgeons appointed for some of the duties which have been described, must vary to a certain extent according to accidental circumstances, but are usually ordered on the following principles. At the chief general hospital at the base is an administrative medical officer of general rank, with deputy surgeons-general or surgeon-major and surgeons in charge of divisions and wards, together with a supplementary surgical staff to fill vacancies as they occur in the intermediate and field-hospital establishments. Each intermediate hospital is placed in charge of a surgeon-major, with surgeons to assist him on the same scale as in the movable field-hospitals. In the field

are usually: the principal medical officer of the whole army, he being at head-quarters, on the staff of the general commanding in chief; divisional administrative medical officers with their divisions; surgeons attached to regiments; and the medical officers allotted to the field-hospitals, and the bearer companies, with a few others for special duties.

The principal medical officer of the army is assisted in the direction of all matters belonging to the hospital and medical arrangements by a field inspector, who performs such supervising and other hospital duties over the whole field of operations as the principal medical officer may direct. A quick, active, observant, and at the same time, judicious officer is required for this post. A medical officer is attached to the quartermaster-general's department as sanitary officer to the army. The medical officer selected for this office, which is one of the highest importance and requires very special qualifications, has been usually personally recommended by the Director General, and directly appointed by the Minister of War. His functions and responsibilities are defined in the 8th section of the 'Sanitary Regulations,' issued in December, 1876.

In the distribution of army medical officers to the different kinds of duties which they have to perform, other qualities, in addition to the necessary professional acquirements, have often to be taken into account. The surgeon-major in charge of a bearer company must be a disciplinarian, active and strong, and a fearless rider. He should be gifted with tact, discretion, and knowledge of character, that he may judiciously guide and control the varied personnel concerned with his charge. He should have a quick perception of the leading features of ground and some acquaintance with military exigencies, in order to dispose of his bearers, and to establish the dressing stations, with the best advantage. The surgeon-major in charge of a field-hospital need not have some of these qualities in the same degree; but they are all necessary, in addition to knowledge of hospital management, to enable him to discharge the duties of his position with credit. They are qualities which become less needed in the medical officers on duty at intermediate hospitals; and still less in those at general hospitals, where methodical habits, the power of close application, and other sedentary qualities, are often of most importance, as regards the duties which have to be done. Unless due consideration is given to these points in the selection of medical officers for particular charges, especially for such a charge as that of a bearer company, failure must be expected. Under any circumstances, such charges present special difficulties for medical officers who have not been habituated to them: but these difficulties will be greatly increased if the most suitable are not chosen for meeting them. Failure, under such circumstances, will

be less the fault of the medical officer having the charge, than of those who placed him in it.

The following table furnishes an estimate of the probable number of medical officers of each grade which will be required in future wars to be in the field with an army corps consisting of 36,800 men of all ranks:—

Component parts of Army Corps	Description of Medical Officers	Number
GENERAL STAFF.		
Hd. Quarter Staff of Army Corps	Surg.-Gen., Principal Medical Officer	1
	Deputy Surg.-Gen., Sanitary Inspector	1
	Deputy Surg.-Gen., Field Inspector .	1
	Surg.-Major, Sec. to Prin. Med. Officer	1
	Surgeon in medical charge of Head Quarter Staff	1
Staff, 3 Divisions	Deputy Surgeons-General . . .	3
	Surgeons-Major	3
INFANTRY.		
21 Battalions	Surgeons-Major, or Surgeons . .	21
CAVALRY.		
3 Regiments	Surgeons-Major, or Surgeons . .	3
ARTILLERY.		
Horse Artillery, 4 Batteries .	Surgeons	4
Field Artillery, 5 Batteries .	Surgeons	5
ENGINEERS.		
Divisional & Reserve, 4 Companies	Surgeons	4
Pontoon Train, 1 Troop . .	Surgeon	1
½ Telegraph Troop . . .	Surgeon	1
4 Bearer Companies . . .	Surgeons-Major	16
	Surgeons	16
12 FIELD-HOSPITALS.	Surgeons-Major	36
	Surgeons	48
	Total number of medical officers .	166

The grades and respective numbers of surgeons in the field with an army corps are, therefore, according to the table as follows:—

Surgeon-General . . .	1
Deputy Surgeons-General	5
Surgeons-Major	56
Surgeons-Major, or Surgeons . .	24
Surgeons	80
Total . . .	166

By present arrangements, junior surgeons-major can always take the places of surgeons when necessary.

The foregoing estimate is based on the understanding that the field-hospitals are to be evacuated, and all the sick and wounded of the army corps to be transferred, as rapidly as practicable, to

the intermediate hospitals in the rear, and to the general hospital at the base of operations. If the administrative staff at the base of operations, and the executive personnel for the 13 field-hospitals allotted for use at the base and along the line of communications, be added to the estimate already given, the numbers will be as follows: in the field, 166; 13 intermediate and base hospitals, 91; administrative staff at base, 6; or, a total surgical establishment for an army corps of 263 surgeons.

Supplementary medical officers.—No number can be fixed for the medical officers who have to accompany the convoys of sick and wounded from the field-hospitals to the intermediate hospitals, and to the general hospital at the base, or for those with the invalids proceeding from the base of active operations home to England. These numbers will vary with the varying necessities which the military operations give rise to, the nature and amount of the transport, and many other circumstances; in the same way as the number of hospitals opened must depend upon the changing exigencies of the war, and the state of health of the troops engaged in it. There must always be a reserve of surgeons at the general hospital at the base of operations, so that, when medical officers are detached from the field or intermediate hospitals for special purposes, they may be replaced from this supplementary staff; just as surgeons, despatched from the base of operations to England on duty, on account of ill health, injury, or any other cause, have to be replaced by others from England. Whatever may be the number of the surgical staff assigned to troops proceeding on active service, a general reserve of one-fourth of that number ought to be maintained, in order to have the means ready for meeting unexpected demands, and replacing casual losses from sickness or injury.

B. THE HOSPITAL AND AMBULANCE ESTABLISHMENTS NECESSARY AND THEIR ORGANISATION.

General remarks.—Previously to the changes introduced in the Army Medical Department in 1873, there were only two kinds of hospitals in the British army: regimental and general hospitals. The organisation of each of these establishments was laid down in the Army Medical Regulations of 1859.

But in time of war, when an army was operating in the field, it always happened that the regimental hospitals were so reduced in their limits of capacity, that, in fact, they practically ceased to exist. Had they been maintained, they would have interfered with one of the most essential qualities of the army—a quality now become more important than ever,—viz., its mobility. On the army going into cantonments or winter quarters, or becoming stationary for any lengthened period, the regimental hospitals might be ex-

panded, but only to be again reduced on the army assuming active movement. On the other hand, general hospitals, which served the purpose of preventing regimental hospitals from being encumbered with patients, were always increased in number and importance according to the nature and duration of the campaign. Such general hospitals must always exist in time of war, and, as they have to be established in situations possessing certain definite relations to the army moving in the field, they are usually distinguished by names in accordance with these positions.

It will be convenient to study the hospital establishments in the order in which they are usually formed on a theatre of warfare, viz. from the base of the military operations, to the field of battle. Regarding them in this way they will consist of: (1) the principal general hospital, and its subsidiary hospitals at the base of operations; (2) intermediate hospitals; and (3) field hospitals, including (4) dressing stations, and (5) regimental stations. The necessary communications between these hospital establishments will have to be maintained by (6) field ambulance trains; (7) railway ambulance trains; or (8) hospital ships. The latter will also be used for communicating with (9) the permanent general hospitals in England.

The nature and formation of each of these several establishments, and the purposes they subserve, will now be described.

(1.) **The principal general hospital at the base of operations.**—When an army operating against an enemy belongs to a continental power, the principal general hospital at the base is placed at the most convenient situation near the frontier. When an expeditionary force starts from an insular country like Great Britain, it is usually established in a suitable building near a sea coast, at the place where the army has been collected, and from which it has started for its special destination. Into this hospital the soldiers, who have become disabled from injury or illness in the transports since their departure from England, are at once received, and, subsequently, those who fall sick while remaining at the place of rendezvous. Here, also, after a time, the great bulk of the sick and wounded from the troops operating in the field are gathered. From it the patients who recover are sent directly up to the army. Those who are not likely to convalesce for a long time, or who are permanently disabled by their wounds, are despatched from it by hospital ships or transports to England. The stores required for the surgical service, the apothecary's and all other hospital stores, are also usually received here as they arrive from home; and from it the principal medical officer in the field draws the supplies which the field-hospitals from time to time require. The nucleus for the establishment of this hospital will in future be obtained from the personnel and equipment of one or more of the 25 field-hospitals allotted to an army corps, according to need. The principal general

hospital at the base is usually the first general hospital opened, and the last closed, in a campaign.

If, as the war advances, the hospital first established becomes unequal to meet the demands made upon it for accommodation, other hospitals have to be opened, either in buildings, or under canvas, in its neighbourhood. These remain subordinate to the principal general hospital just described, and are, indeed, merely branches of it. They usually draw their supplies from it, and are directed, so far as the conduct of their general administration is concerned, by the principal medical officer at the base.

2. **Intermediate hospitals.**—These are so called from being situated between the general hospital at the base of operations and the ambulances, or movable field-hospitals, with the army itself. The intermediate hospitals should be so placed along the lines of communication with the base, whether railroads or ordinary roads, as to receive without difficulty the wounded from the field-hospitals. They should be sufficiently equipped and provided to be able to retain the patients who are not in a fit state to be sent on to the principal general hospital at the base, or who are waiting for opportunities of being sent there.

It is a recognised military principle that the sick and wounded of an army in face of an enemy are, whenever practicable, to be passed without delay from the field to reserve, or intermediate, hospitals in rear. Disabled troops are not merely so many inefficient men, requiring food, care, and attention, but they act as impediments, and often seriously interfere with the plans of a commander, who may find himself compelled to make long and rapid marches. It is impossible to carry the sick and wounded along with troops under such circumstances. Neither can the patients be left in places devoid of due military protection: nor could the field surgeons be spared to be left behind with them if they were so placed, for these medical officers are constantly wanted with the army moving in the field, to meet the case of a fresh engagement occurring with the enemy. The field-hospitals on the establishment of the main body of troops should be kept in the lightest marching order possible, ready to afford temporary help and treatment to whatever number of wounded may result from the operations in which the troops are engaged.

Hospitals have therefore to be established on the line of communication between the base of operations and the position of the army, as the latter advances. These constitute the intermediate hospitals under consideration. Even without any conflict with an enemy, the men who fall sick on the line of march, require provision of this kind to be made for their reception. The number who thus succumb, even under the most favourable circumstances, when troops are marching, appears remarkable. It is calculated that from 4 to 5 in every 100 men will require hospital treatment, in

the course of a ten days' march. In an army corps of 36,000 men, this means from 1,440 to 1,800 patients to be treated. If circumstances be unfavourable—whether as to climate, ground, diet, weather, or otherwise—the number of sick may be expected to be proportionably increased. By the arrangements of 1875, before referred to, 25 field-hospitals, each constituted for the reception of 200 patients, formed the complement of an army corps. It has since been arranged that only 12 of these shall move with the army corps, the remaining 13 being placed at the base of operations and along the lines of communication. A proportion of these field-hospitals may, therefore, be utilised for the reception of the patients dropping from the force on its advance; and, whether opened at depôt stations in villages, or in detached buildings, or placed under canvas in a camp, they will become converted for the time into intermediate hospitals. They will start with the force complete in stores and utensils, the same as the movable field-hospitals, and with a similar personal staff. The only difference will be that the wagons need not be of the service patterns, but may be of the kind in ordinary use in the country.

The number of intermediate hospitals opened during a campaign must depend upon the nature of the country in which the military operations are carried on; the distance to which an army penetrates: the changes in the direction of its movements; and the nature of the communications, whether ordinary roads, railroads, or water, which exist between it and its base of operations. Their positions must be determined under the orders of the officer commanding the line of communications, for he alone can be aware of the situations which will be safe for the purpose, where the necessary supplies can be brought, and to and from which the sick and wounded can be moved with least risk of interruption; while, in all professional concerns, they will depend on instructions from the principal medical officer at the base, or the field director, or sanitary officer, acting under his orders.

3. **Field-hospitals.**—These are the hospital establishments which are actually with the troops and take part in their movements. The only field-hospitals provided for by the army medical regulations of 1859, consisted of regimental hospitals. Additional hospital equipment was allotted to brigades and divisions, so that brigade or divisional hospitals might be opened if ordered, but no plan of organising them was described. They have only been actually established in time of war when they were necessary to add for a time to the accommodation of the regimental hospitals, or under circumstances when the military operations have been of a comparatively permanent nature, as in a siege.

'Flying field-hospitals,' agreeing in some measure with the 'ambulances volantes'[8] of the French army, or dressing stations of other armies, have been occasionally improvised in the British

service, to meet the immediate wants of the wounded on occasions of actions with an enemy. But the army medical regulations never included any directions for constituting such flying hospitals. No particular equipment was fixed for them, any more than, as already mentioned, a special personnel.

The regimental hospitals, according to the regulations of 1859, were each calculated to receive, and to treat as in a hospital ward, 20 patients. Bedding and all the necessary articles were ordered to be furnished for the purpose. In the brigade equipment similar provision was made for 50 more patients, or, when both brigades were together, for 100 more patients. Each regiment, or battalion (the terms are used interchangeably in the regulations) was then calculated at 850 men; each infantry brigade at 2,500 men; the division at 5,000 men. The field-hospital provision, being for 120 patients in the six battalion field-hospitals, with a reserve provision for 100 more for the whole division, was, therefore, in the proportion of a little more than 4 per cent. of the total force. The whole of the hospital equipments, medical comforts, and transport, for this proportion of patients, was ordered by the regulations to accompany an army in time of war—the battalion establishment to be with each battalion, the divisional with each division. The regulations also made provision for additions to the equipment in case the proportions named should be required to be exceeded. Shortly after the regulations were published, the question forced itself on the minds of those who considered the subject, whether all these hospital establishments could move about in company with the troops to which they had been assigned. Could every battalion carry with it a complete hospital fitted for 20 patients, the equipment weighing 1,157 lbs., and therefore involving a considerable amount of transport, in addition to the medical panniers and the ambulance wagon for carriage of patients, without seriously interfering with the military operations of the troops? Another question which arose was—does the multiplication of hospital articles, some of which can only rarely be required, which this system of many small separate hospitals involves, offer any special advantages in time of war? These, and other like questions, have been answered in the negative. The difficulties, and unnecessary expenditure, entailed by the system are now generally acknowledged. The experience of all the military operations in which British troops have been engaged of late years, has proved the impracticability of burthening regiments with such heavy hospital establishments in time of war. But although regular regimental hospitals, moving with an army in the field, are now out of the question in modern warfare, a battalion cannot be left without any surgical assistance close at hand. This, however, must be of a very limited character. One or more battalion surgeons, with trained orderlies to assist

them, and one or two attendants, each carrying a 'Medical Field Companion,' will be required to attend to casual wants on the line of march, at halts, slight skirmishes, and to join in giving assistance at the field and dressing stations in case of a general action. If the plan of telling off some men of the battalion as regimental bearers be carried out—and it is now universally acknowledged to be a necessary part of the field-hospital organisation—then the supply of a certain number of stretchers becomes essential. No other battalion establishment is practicable in the present day, nor is, indeed, needed when suitable bearer and field-hospital establishments are organised. The battalion stretchers will be eight in number, one to each company, and will be carried on the company carts, with the company equipment and light baggage, on the line of march. When before an enemy the stretchers would be removed from the carts, and carried by the bearers, under the directions of the battalion surgeon. The employment of regimental hospitals has been discontinued for several years past in the autumn manœuvres in England, and field-hospitals of other formations have been introduced; but the facilities and economy of sending men who have been injured or have fallen sick during the manœuvres to the permanent station hospitals, where their wants can be much better attended to, have prevented these establishments from having any but a most remote resemblance to what would be required, were the troops on active service before an enemy. Indeed, field-hospitals are out of place with peace manœuvres in the home country; the only establishments that should be trained to move and work with the troops are the bearer companies. Their legitimate functions would be to give the necessary first assistance to those requiring it, and to conduct all the arrangements for transporting the patients, requiring removal, to the appointed station-hospitals.

Requisite qualities of field-hospitals.—The necessities of modern warfare point to the following as the requisite qualities of field-hospitals. On the occurrence of an engagement with the enemy, they should be capable of receiving the wounded after their first necessities have been attended to elsewhere—with their regiments, or at the appointed dressing stations. They should have all the means for treating these patients, until they can be transferred to intermediate hospitals in rear. They should be capable, as soon as the patients are removed, of being quickly packed up and brought within reach of the army again, should it be advancing, so as to be available for receiving a fresh number of wounded. They should have all the necessary means for temporarily treating patients who fall sick with camp diseases. The foregoing considerations lead to the necessity of each field-hospital being complete in itself—as regards both its personnel and matériel; of its not being of undue size, a matter which is also indicated by hygienic considerations; of its stores

being ample in quantity for several successive contingents of sick and wounded; and of it being so constituted that it can be speedily opened, speedily closed, and easily removed from place to place.

The organisation adopted for the new field-hospitals of the British service, is calculated to answer the purposes just described. The composition of the staff of one of these field-hospitals has been shown in a tabular form at page 440. An army corps will have its complement of these hospitals attached to it—each being arranged, as before mentioned, for accommodating 200 patients. Only so many of them need be employed as circumstances render necessary; it will devolve on the principal medical officer of the force to give the necessary directions on this subject. Those not required for use may be made to move at a suitable distance behind the army, or may be kept in a state of readiness at a particular spot, to move wherever ordered.

Working of field-hospitals.—The following will probably be the mode of working the field-hospitals. If a general battle be expected, the field-hospitals are brought as close to the army as circumstances permit. A village, a factory, a farm, or a mansion with outbuildings, is selected as the place for a hospital; here the equipment is unpacked, and all surgical proceedings likely to occur prepared for. The field-hospital thus established is made conspicuous by the hospital flags, and its site, and the routes to it, made known to the officer directing the operations of the bearer company. The wounded who are brought can remain under treatment in it as long as necessary, but it is not intended that they should remain beyond a few days, especially if the troops make an advance. All patients that can bear removal are, therefore, evacuated upon the nearest intermediate hospital in rear as soon as practicable. If there are patients who are not in a condition to be so disposed of, one section of the field-hospital establishment may remain to take care of them, and the other section move to the army again. Or, if circumstances render it desirable, the whole field-hospital may remain and be changed into a stationary intermediate hospital, another field-hospital being sent to the front in its place.

Position of the field-hospital establishments on the line of march. This is a most important arrangement to be settled, for the field-hospital establishments are necessarily bulky. On the one hand, they should not be permitted under any circumstances to interfere with the movements of the troops; on the other hand, they should be near and ready for use whenever they may be required. These points should be fully considered in defining the positions of the field-hospital establishments on the line of march, which should correspond, as closely as possible, with what they would have to be in case of the force becoming engaged. The importance of fixing suitable positions for them becomes especially felt when

it is a matter of doubt at what moment an enemy may be encountered, and a large number of wounded may require hospital assistance. It has been too often the case that the whole of the hospital establishments have been ordered to be in rear of all the heavy baggage of the troops which they have been accompanying; so that they have been far out of reach at the time of need, with obstacles between them and the wounded that no exertions could overcome, until a long period of delay had elapsed.

When the system for surgical help in the field, described in these remarks, is in working order, and a body of troops is on the line of march in an enemy's country, the equipment for affording the first help on the field itself should move in rear of the respective battalions, in the company's carts; while that of the dressing stations, with the first line of ambulance conveyances, in charge of the bearer company, should be distributed in part with the advanced guard, but chiefly with the main body, in rear of each divisional column. The second line of ambulance conveyances might move, and be halted, half a day's march in rear of the troops. A portion of the field-hospitals should be distributed among the main body of troops, moving in rear of divisions; while the remainder should accompany the heavy baggage columns, and be in reserve.

The following shows the manner in which the 3 sanitary detachments and 12 field-hospitals were distributed, when the 5th German Army Corps, to which they belonged, was marching during the Franco-German war.[9]

ADVANCED GUARD.

1st Infantry Brigade of the 9th Division, with Cavalry, Artillery, and Engineers.
Half the Sanitary Detachment, No. 1.
The Light Baggage of the Advanced Guard.

MAIN BODY.

2nd Infantry Brigade of the 9th Division, with Artillery.
Half the Sanitary Detachment, No. 1.
Field Hospitals, Nos. 1 and 2.
Light Baggage of 9th Division.
Two Brigades of the 10th Division, with Cavalry, Artillery, and Engineers.
Sanitary Detachment, No. 2.
Field Hospitals, Nos. 3 and 4.
Light Baggage of 10th Division.
Battery and Infantry Ammunition Wagons.
Sanitary Detachment, No. 3.
Field Hospital, No. 5.

TRAINS.

Provision Columns.
Heavy Baggage.
Remount Depôt.
Field Hospitals, Nos. 6 to 12.
Field Bakery Column.

It will be seen from this arrangement, that, in case of the advanced guard becoming engaged, a section of a sanitary detachment would be at hand to join with the battalion sanitary personnel in aiding the wounded, and to assist in carrying them away. If the engagement assumed larger proportions, so that a whole division was brought into action, the whole sanitary detachment would be made available for service, and two field-hospitals could be opened, if necessary. A similar amount of assistance was at hand with the second division, in case of need: and still further aid, should the fighting be prolonged and the number of wounded increased, was within reach, in rear of the whole main body. At a still greater

distance off, with the train and columns of the Army Corps, seven field-hospitals were in reserve; either to supplement those with the troops, in case of additional need, or to replace them, in case the hospitals occupied by wounded could not be evacuated, and had therefore to remain behind on the main body making an advance.

No part of the equipment to be separated from field-hospital establishments.—It has been explained in the foregoing remarks that the organisation and equipment of a field-hospital for 200 wounded men, are such as to cause it to comprise everything necessary for the care, and treatment, of that number of patients. It should be equally understood that the provision laid down for the field-hospital cannot be interfered with, without, to a corresponding extent, impairing its efficiency. Each field-hospital is arranged to admit of division into two portions. The personnel is organised with this object in view, and, for this purpose also, the surgery stores are placed in two pharmacy wagons, and the bedding, utensils, and other hospital equipment, are disposed in four store wagons. No division is admissible beyond this separation into two equal parts. It must not be supposed that one of the bedding and utensil store-wagons, or one of the pharmacy wagons, can be taken away from the hospital, and be sent to another part of the field without disarranging the whole establishment. The pharmacy wagon and two bedding and utensil wagons may be regarded as the unit in respect to stores for a field-hospital. The latter would be comparatively useless without the surgical stores in the pharmacy wagon; and the surgical stores in the pharmacy wagon would be very limited in use without the hospital bedding and utensils. It is not unlikely the supposition that such abstractions, as I have indicated, may be made from the field-hospital without detriment to it, will occur to some persons who have not considered the whole subject. Such an attempt, if made, will surely lead to confusion in the medical administration, or inadequate assistance to the wounded. The articles contained in the equipment wagons of a field-hospital have not been calculated for the wants of the first or second lines of surgical help. Had they been, the field-hospital establishments would have been rendered needlessly cumbersome. The pharmacy and equipment wagons of the field-hospitals contain articles such as medicines, bedding, and others which would not be required, and do not contain a sufficiency of the articles which would be required at the more advanced help stations. The wants at the field, transfer, and dressing stations—the organisation of which has yet to be considered—are special, and economy dictates that they should be specially and separately provided for. Moreover, the detachment of parts of the field-hospital equipment, in the way mentioned, must inevitably lead to disaster in the field-hospital itself. The regulated arrangements for the hospital service would be disturbed; a division of responsibility would be created; impor-

tant articles of equipment, when once separated from the establishment to which they belong and diverted to other purposes, would frequently fail, under the circumstances of warfare, to regain their original positions; and the special characters of a field-hospital—its completeness and ready mobility—would be lost. The essential feature of the field-hospital is its integrity in all respects—in its personnel, in its equipment, and in the transport for that equipment. It should have no more of one or the other than is necessary for its wants and its even working; and, if it be organised on these principles, it is obvious that even a temporary abstraction of part of its personnel or equipment must for the time destroy its essential character, and proportionably mar its efficiency.

4. Dressing stations.—These establishments are of a much lighter, and still more movable, character than the field-hospitals, being only organised for affording preliminary assistance to the wounded. They assume increased importance when the field-hospitals are placed a long distance off from the field of battle, as they usually have to be in the present day. As before mentioned, they have hitherto been formed, when they have existed at all in the British service, out of any regimental or staff medical officers and attendants, and any articles suitable for the first dressing of wounds, that might be at hand and available for the purpose. In future they will have a definite constitution, and fixed supplies of equipment.

Organisation of dressing stations.—Dressing stations, as now organised, are formed by the Surgical Staff, and Army Hospital Corps men, of the bearer company. They are provided from the stores of the company with the necessary equipment. They do not depend at all upon the field-hospital establishments either for surgeons, attendants, or dressing materials. At the same time there is no reason why some of the medical officers of the field-hospital establishments should not be lent to assist in the duties of the dressing stations in the early period of an action, at the time when the field-hospitals are being opened and got ready for patients, and there is extra pressure at the dressing stations; but on no account should the matériel of the two establishments be mixed together, for reasons which have been already mentioned when describing the field-hospitals and their organisation.

All the equipment carried for use at dressing stations should be of the most movable description; not only that it may be readily kept up with the troops while they are on the march, but also because, from the nature of these flying hospitals, they may suddenly have to change their position at any time during the progress of an action.

The number of dressing stations established on a given occasion will have to vary with the extent of ground along which the fighting is going on, and the facilities of bringing the wounded to

them. They should not, however, be multiplied or dispersed more than circumstances actually require. A sufficient number of surgeons and surgical stores should be collected at each dressing station to permit an economical and methodical division of duty, as well as that there may be sufficient material resources for meeting all the various wants that are likely to demand attention. If only one dressing station be formed, all the surgical wagons, store-wagons, and water-carts, of the bearer company, should be collected at it, the operating tent should be pitched, and the whole disposed under the orders of the surgeon-major in charge. If a suitable building can be got, it should be turned to account. If the dressing station be well managed, the medical officer in charge will take the general direction; one or more surgeons will be told off for the systematic examination of the wounded as they arrive; and others, with the requisite hospital aid, for applying the preliminary dressings, or performing any surgical operations that may be regarded as essential and not admitting of delay till the arrival of the patients at the field-hospitals. The duties should be systematised in order to obviate delay, and to prevent interruption in the dispatch of the wounded in regular succession to the field-hospitals in rear.

The complete establishment of a bearer company, including the personnel, equipment, and transport required for the service of the dressing stations, is shown in the following table.

Table showing the Composition and Equipment of a Bearer Company in the Field.

OFFICERS.		**TRANSPORT.**	
Surgeon-Major in charge	1	General service wagons for tentage	2
Surgeons-Major	3	Surgery wagons	2
Surgeons	4	Ambulance wagons	33
Captain of orderlies	1	Equipment carts	2
Lieutenants of orderlies	2	Water carts	2
Transport officer	1	Supply cart	1
Total officers	12	Total vehicles	42
NON-COM. OFFICERS AND MEN.		**HORSES.**	
Sergeant-Major A.H.C.	1		
Sergeants „	10	Riding (officers')	12
Corporals „	10	„ (non-commissioned officers')	3
Privates „	15	Draught	88
Bearers „	95	Spare	6
Sergeants A.S.C	2	Total horses	109
Corporals „	2		
Corporal (saddler) „	1		
„ (wheeler) „	1		
„ (farrier) „	1	**TENTS.**	
Private (shoeing smith) „	1	For officers	6
Drivers „	47	For non-commissioned officers	17
Bâtmen, &c. „	12	Operating tents	2
Total non-com. officers and men	198	Total tents	25

It is to be remembered that the formation and service of the

dressing stations is not the only function of the bearer company, but that the carriage of the wounded to and from them is also performed by it. To avoid imperfect co-operation and to ensure direct responsibility, the whole control of the bearer company is placed in the hands of the medical officer in charge of it. He is answerable, through the officer commanding the troops to which he is attached and deputy surgeon-general of the division, to the principal medical officer of the army for its efficiency.

The outline of the bearer company maintained in time of peace consists only of the surgical and subordinate personnel; the transport and other equipment, the necessary staff of drivers from the Army Service Corps, and the reserve of bearers, will be added on the company being constituted for field service. Like the field-hospitals, the organisation of each bearer company admits of its division into two half-companies. It is not intended that the number of ambulance wagons allotted to the company should all move with the company. They are divided into two columns. Ten wagons move with the bearer company and form the ambulance column of the 1st line; and 23 others, the column of the 2nd line, detached at some distance off in the rear. The former are ambulance wagons of regulation pattern; the latter may consist of local transport when a sufficient number of service wagons is not available. There are four bearer companies allotted to an Army Corps of 36,000 men; that is, one company to each division, and one for the service of the corps troops and cavalry brigade. It might be useful to add a bugler to each company; not merely for the ordinary military calls, but also for the special service of attracting the notice of wounded men after an action—a call for the purpose being introduced and made generally known in the army. There is a regular bugle-call for the wounded practised in the German army. After an action, when it is suspected that wounded men may be lying in woods or thickets, or at a distance, the call is sounded, and the bearers listen to hear if the call is answered.

Field-hospital equipment to be stored ready for immediate use.—The whole equipment for the field-hospitals and bearer companies, in proportion to the number of troops which the government of a country may think right to keep prepared for moving into the field, should always be kept ready for use in time of peace. A great part of the equipment is of a very special character, and cannot be obtained at short notice. Unless this is done, there must always be uncertainty and uneasiness respecting the possibility of procuring the necessary stores, and the special transport for their conveyance, every time that an outbreak of war is threatened. I have seen in Austria and Prussia the articles comprising the equipment of a given number of field-hospitals, and the transport which would be necessary for their conveyance, all stored together; so that, on a sudden declaration of war, the only orders necessary would be for placing a few articles of a perishable nature, such

as medical comforts, in their respective cases, and to pack for taking the field. It is quite as necessary for efficiency to have the field-hospital and bearer company equipment stored ready to meet a sudden emergency of war, as it is to have the fighting equipment ready; and there ought to be no more difficulty in turning one out for use than the other, as soon as the order for doing so is issued.

5. Field or regimental stations. — These are established for affording such surgical help during an engagement as may be demanded for preventing speedy loss of life in particular cases, and for giving any directions to the bearers that may appear of vital importance to the wounded, before they are carried to the dressing stations. Each field station is, therefore, placed closely in rear of the regimental combatants, and is provided only with the most limited personnel and amount of surgical matériel, such as a single surgeon with his personal equipment, and one orderly carrying a Medical Field Companion.

It is useless to attempt to arrange for the performance of important surgical operations under fire. Not to mention circumstances affecting the power of the surgeons to perform them, the wounded men themselves are not in a condition to be subjected to them. The one idea among those who retain their consciousness, is to get themselves carried away from where they are to a place of shelter. The ping of every passing bullet is a source of fresh agitation. There is a vivid impression that delay will only lead to another wound, and that the next one will, perhaps, be fatal. There is no resignation, no calmness—none of the conditions, in short, which ought to be present in a conscious patient who is to be subjected to some serious surgical proceeding; on the contrary, there is a state of nervous excitement, and, as a general rule, a predominant impulse to rush away if only it could be accomplished. Altogether such a patient's state is most unsuited for professional interference. The stretcher-carriers under such circumstances are almost the only friends desired, or likely to be of service. It follows that the only cases to which surgical attention can be given under fire are almost exclusively those of patients who are in a state of dangerous collapse from loss of blood, and in whom the flow can be checked by instant attention. All who know what battle means, are aware that the opportunities of affording this assistance are rare indeed; and, considering how far more useful surgeons may be at the dressing stations and field-hospitals, it seems only reasonable and right that but very few indeed should be sent to practise professional duties at the fighting line. It seems hard to say so, but the strongest argument, perhaps, that can be used for sending any surgeons at all under fire, is that the knowledge of their presence affords some moral support to the troops who are engaged with the enemy.

The number of the field stations organised must, like the dressing stations, vary with the manner in which the troops engaged

are distributed. Probably one to every brigade of three battalions will suffice; the surgeons of two of the battalions being sent to assist in attending to the wounded at the nearest dressing station.

The three stations for help to wounded in the field.—It will be seen that three systems of surgical help to the wounded are kept in view in the organisation of the foregoing field establishments, viz., (1) help of prime urgency at the place of conflict; (2) help of a provisional character at the dressing station; (3) help of a definitive kind at the field-hospital station.

Four kinds of help stations sometimes organised.—Of late years, in European warfare, when the arrangements for assisting the wounded have been well and systematically conducted, there have been practically four stations of surgical aid. This number appears, indeed, to be now almost essentially necessary, in consequence of the great range of rifle shot and modern artillery fire, and of the distance from the combatant line of troops at which this fire causes the dressing stations to be established. On the one hand, it is necessary that the bearers should not have too great a distance to carry the wounded on stretchers from the scene of action to the dressing station, so as to be drawn away from the immediate rear of the combatants for too long a time; on the other hand, it is necessary to prevent the wounded from being too long without an opportunity of receiving surgical help. When four stations are arranged they are thus divided:—

1. First Help-Station, or station for help of prime urgency at the fighting line—'the field, or regimental station.'

2. Second Help-Station. This will be at the place where the wounded can be most conveniently collected for transfer from the hand-stretchers to the ambulance wagons. No delay that can possibly be avoided should take place at this station. If any surgical help be given, it should only be of the same kind as that at the fighting line; for arrest of bleeding if there be active hæmorrhage; for impromptu protection of broken limbs, if none has been previously applied; or for hasty readjustment, if manifestly needful, of any means of protection that have been previously applied at the field station. This may simply be distinguished as the 'transfer station.'

This station should merely be regarded as the point where, from the nature of the ground and other circumstances, it becomes possible to employ wheeled transport, instead of bearers, to carry the wounded to the dressing station; and where, therefore, it is convenient to deposit and collect the wounded as they are brought from the field, until they can be taken away by the wagons. It is only described as a separate station of help, in order that a more clear and methodical notion of the manner in which the various stages of assistance have to be afforded to wounded men in the field may be acquired.

3. Third Help-Station or 'Dressing Station'; the '*Verband-*

platz' of the Germans, or '*Place de pansement*' of the French. This is the station for the usual provisional assistance prior to removal to the field-hospitals.

4. Fourth Help-Station, or the 'field-hospital'; the '*Feld-lazareth*' of the Germans, and the '*Hôpital de champ de bataille*' of the French.

The four stations for help behind the combatants will then be: (1) the field or regimental station; (2) the transfer station; (3) the dressing station, and (4) the field-hospital. The positions selected for them must vary in accordance with peculiarities of ground, the nature of the engagement, and many other circumstances; but some general principles will always have to be taken into account, in making the selection of them.

Position of the 1st or 'field station.'—This will always be in the immediate rear of the fighting line, moving as the combatants move, whether advancing or retiring. The duties of this station must be performed under fire: their nature necessitates this.

Position of the 2nd or 'transfer station.'—The position of this station should be regulated by the following considerations: It should be (*a*) sufficiently clear of rifle-shot from the combatant force opposed to the troops in whose service it is formed; (*b*) it should approach the front as closely as is consistent with the requirement just named, so that the wounded may be got into the wagons as early as possible, and the bearers left free to return to the front for more wounded; and (*c*) it should be at a place practicable for wheeled vehicles.

The first consideration (*a*) will require the position to be maintained at from about 700 to 900 yards from the rear of the troops engaged. The extreme range of infantry fire is about 1,400 yards, and as the fighting line of troops in modern formation occupies at first about 600 yards, the distances named will place the 'transfer station' clear of this fire. The second consideration makes it important that this distance should not be exceeded. The third (*c*) that the station should be close to a lane or road, or, in their absence, on ground as nearly level as can be obtained.

Position of the 3rd or 'dressing station.'—This station should be (*a*) out of the range of artillery fire from the enemy; (*b*) at a spot easily reached by the wheeled vehicles, and on the road towards the field-hospital station; and (*c*) near a supply of water, if such can possibly be obtained. The first requisite (*a*) will probably be met by placing this station about 1,000 yards in rear of the transfer station, the range of field artillery being now from 2,500 to 3,000 yards; the second (*b*), by placing it at the side of a road leading to the village or place where the field-hospital has been stationed; the third (*c*), by selecting a site near a well, spring, or running stream. At the same time, as water-carts form part of the equipment of the bearer company, a fair amount of

water should be forthcoming even though no natural supply may be at hand.

Position of the 4th or 'field-hospital station.'—This should be sufficiently far from the actual scene of conflict to be safe, in a considerable degree, from risk of being brought within the sphere of fighting—either in the movements of the troops while manœuvring, or in case of a retreat of the force to which the hospital belongs. Probably no position can be taken where the hospital will be entirely free from these risks, without, at the same time in a great degree destroying its utility; but a prudent selection of site may lessen them very materially.

In respect to distance, from two to four miles in rear of the combatants will probably be found to answer best the purposes of the field-hospitals. This will not be too far for communication by wheeled vehicles, and will generally be sufficiently safe as regards the wounded. Circumstances may render a distance of five miles, or even further, from the place of fighting necessary for the position of the field-hospitals, as was shown in several instances during the Franco-German war. The field-hospitals should not be placed nearer than the shorter distance named, under any ordinary circumstances, with an attacking army. The accidental situation of a town, or suitable farm or country house, will often determine the choice of the locality for a field-hospital. No commanding position likely to become one of prominent strategical importance, no village that is likely to be occupied to shelter an advanced, or a detached body of troops, or for any military purpose, should be chosen for the site of a field-hospital. If possible, a situation on the main route of the army should also be avoided, as being likely to become encumbered and blocked by the store-transport and other heavy vehicles. At the same time a field-hospital should not be opened far from the main route, or the power of ready evacuation of it may be lost, and, possibly, there may be difficulties in obtaining certain supplies. All these considerations show the necessity for military experience, as well as for knowledge of surgical duty, on the part of those on whom it devolves to make such arrangements.

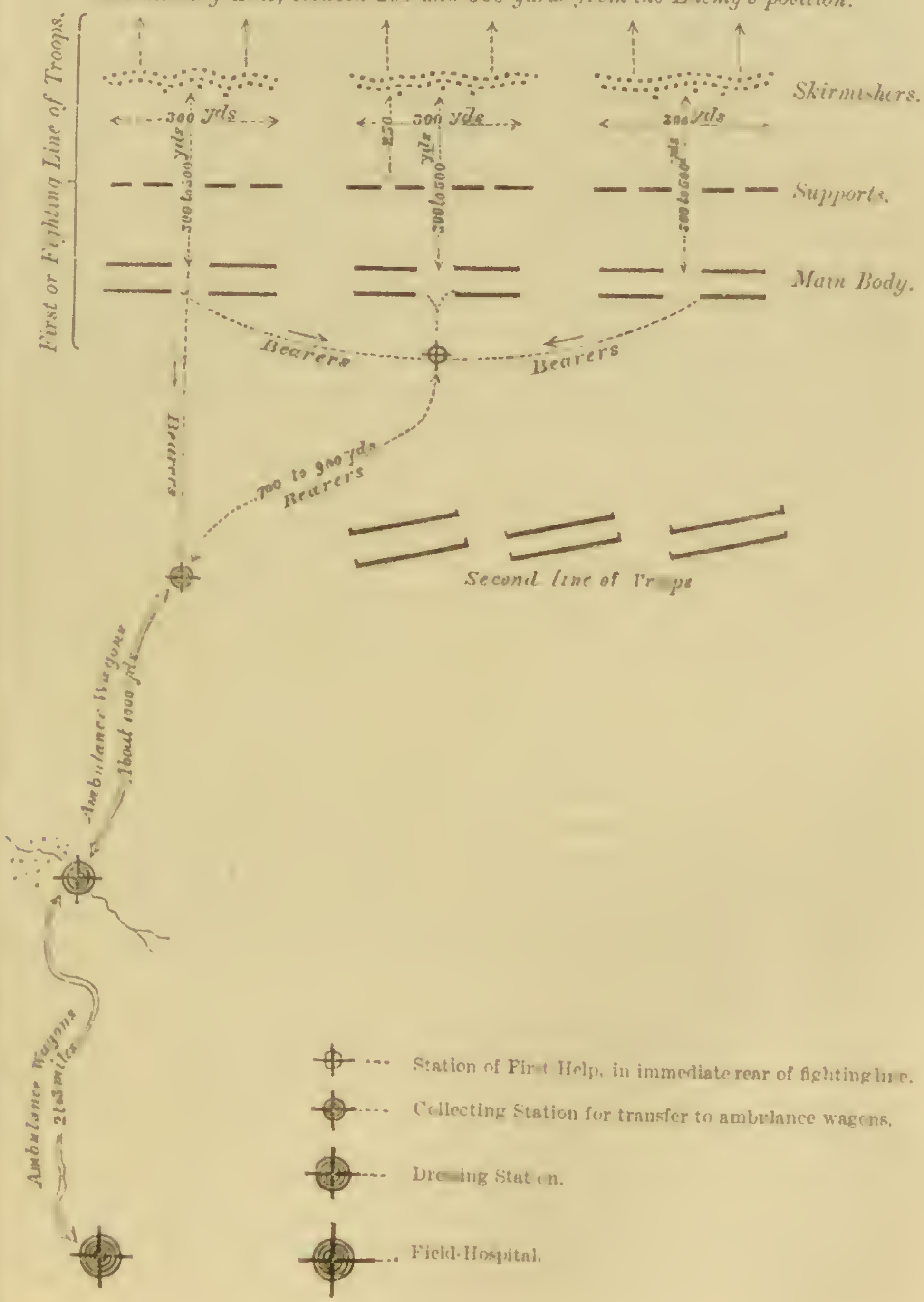
As before mentioned, the directions given concerning the particular positions of the several stations for carrying on the early treatment of the wounded must only be regarded, like many other regulated military dispositions, as being of the nature of general principles. It is to be understood that they are liable to be modified in practice, as circumstances may render necessary, according to the varying nature and extent of the military operations, the features of the terrain, the personnel and matériel at disposal, and other such matters. The principal medical officer of the army corps, on whom the responsibility for this branch of the military service rests, or his administrative representatives who are

vested with the necessary authority, will have to decide on these and all similar arrangements.

The following sketch will serve to illustrate the relative positions of the successive surgical help-stations which have just been described, during an action with an enemy. Three battalions are supposed to be attacking.

Fig. 38.

Skirmishing Line, between 200 and 300 yards from the Enemy's position.



6. **Field ambulance train establishments.**—During the time that a battle is in progress, and while some of the wounded are being attended to and dressed at the several help-stations to which they have been carried, the conveyance of other wounded from the field to these stations is necessary. Those also who have been dressed must be taken to the field-hospitals. A constant circulation of transport is required all the time the action lasts, and so long as any wounded men require to be carried away. At a subsequent period, the wounded, who have been treated in the field-hospitals and who admit of removal, must be taken to the intermediate hospitals, and from these again, in due course, to the general hospital at the base of operations. These operations lead to the necessity for certain ambulance train establishments, the principal material part of which consists either of vehicles conducted on ordinary roads, or of carriages on railroads. By whatever means the wounded are being moved, they require a certain amount of care and treatment during their removal; so that, for the time being, these ambulance trains, when they are conveying wounded, may be regarded as moving hospitals. The constitution of the field ambulance train has already been indicated in describing the composition of the bearer company, and the ambulance columns of the first and second lines which form part of it. As the essential purpose of the ambulance train establishment is the systematic and careful removal of the wounded from station to station; and as many of the wounded must be in a very critical condition, requiring skilled care and attention while in the hands of the ambulance train; it follows that the establishments must not only comprehend a number of transport vehicles with their drivers, and officers for supervising the execution of these duties, but also a certain staff for affording surgical assistance. This help is given, so far as the field ambulance train is concerned, by the surgeons and men of the army hospital corps who form part of the establishment of the bearer company. In the case of convoys of wounded moving to intermediate hospitals by road, or sent to distant hospital stations by railway, the necessary surgical supervision and help have to be provided under the directions of the principal medical officer at the base of operations, and the field director of the lines of communication with the base.

7. **Railway ambulance train establishments.**—When a body of wounded or sick soldiers are sent by railway, a certain establishment of surgeons and attendants must accompany them to minister to their wants in the carriages on the way and during halts at railway stations. What this establishment is to be, in proportion to the numbers sent, must vary according to the distance of the railway journey, the kinds of carriages employed, the means of communication between them, and other circumstances. With the exception of particular instances in which specially constructed trains, and

well-organised establishments, were engaged in the removal of wounded during the civil war in the United States and the late Franco-German war, the transport of wounded by railway has been hitherto usually attended with much suffering to the patients and aggravation of their injuries. This subject has been much studied on the continent of Europe, and many experiments have been made to determine the most appropriate forms of carriages, and the best organisation, for railway ambulance service. It will be again referred to in the chapter on Transport. No regulations have been as yet issued in England regarding the constitution and management of railway ambulance establishments in time of war.

8. **Hospital ships.**—These vessels are of great importance as regards the comfort and welfare of wounded troops, and there should always be a proportion of them, properly fitted, and thoroughly organised in their hospital staff, whenever the enemy to be encountered is one at a distance from our own shores. Hospital ships should be arranged to accommodate both disabled officers and men: however comfortably officers may be provided for in hired transports, they cannot be so well cared for, when requiring surgical treatment, as when they are placed in vessels regularly provided with all the essentials of a hospital.

Hospital ships are required more especially as means of separating the sick from the healthy on board the transports at the first place of rendezvous if this be ordered to take place at sea, while the force is on its way to the scene of military operations; for the reception of those who are too sick to land on the arrival of the force at its place of destination, if this be a hostile country; for the reception of casualties which may occur in effecting the landing itself; and for the periodical conveyance of the sick and wounded, when a sea intervenes between the field-hospitals and the general hospital at the base of the military operations. They are also most desirable for the transport of wounded invalids who are incapacitated for further service in the field, and who are, therefore, ordered to be sent to England, either for treatment or for discharge from the army. A hospital ship may also be used with advantage as a *stationary* hospital, when climatic or other reasons render treatment in a sea-coast hospital objectionable, as was the case during the late expedition to the West Coast of Africa. It then assumes the characters of the principal general hospital at the base of operations. When the invasion of the Crimea was undertaken, cholera was prevailing among the troops, both during the passage from Varna to the place of rendezvous of the fleet at Baldjik Bay, and from the latter to Kalamita Bay where the army landed; and, on this account, properly fitted and equipped hospital ships would have been an invaluable resource. None, however, accompanied the expedition. Ordinary transports were afterwards used for hospital purposes, as well as for conveying the wounded from the

Crimea to the principal general hospital at Scutari; but they were extremely ill-suited to the purpose. They were generally not sufficiently high between decks, not provided with the necessary fittings for the reception of wounded men, not clean, badly ventilated, and without proper attendants. The experience which was then gained led to improvements in this regard. The regulations now order that hospital ships are to be provided on all occasions when an army is about to take the field; the Director-General arranging, under the Minister for War, the amount of hospital transport required, with the nature and extent of the fittings, equipment, and supplies of all kinds necessary for the sick and wounded expected to occupy them. In the Chinese war of 1860 two hospital steamships were despatched from England fully equipped;[10] but since that date, great improvements have been made in their construction and fittings. The most perfect and the most successful example hitherto afforded of a hospital ship, was the 'Victor Emanuel,' which was arranged and fitted under the directions of the present Director-General, Sir William Muir, for service on the West Coast of Africa during the Ashanti war of 1873–74, and in transporting the wounded from that station to England. The organisation and arrangements of this hospital ship, with some improvements which were suggested by the experience gained during the expedition, will no doubt form the standard for hospital ships in all future wars in which Great Britain may be engaged.

The military arrangements in hospital ships must include the necessary number of surgeons, hospital attendants, cooks, dispensers of medicines, and, in short, a complete hospital establishment, according to the number of patients intended to be accommodated in the ship. The functions of the naval part of the establishment are restricted to the management of the ship and its concerns.

9. **Permanent hospitals at home.**—A description of the establishments for permanent hospitals at home will be found in the Army Medical Regulations. The wounded, as they arrive in England in the hospital ships, may, if sufficiently recovered, be sent to the depôts of their regiments, but the majority will be sent to the principal Invaliding Hospital at Netley. In case this should not be capacious enough to admit all the invalids who may be sent home by the hospital ships, some of the larger station hospitals will be arranged for receiving them, or fresh hospitals will have to be opened. The establishment of the Invaliding Hospital at Netley has some special features, but a description of them would be foreign to the purpose of this work.

National aid societies.—In each of the leading countries of Europe, Great Britain excepted, there exists, in official relation with the War Ministry, a National Society for aiding the sick and wounded soldiers of the country in time of war. These societies are so organised as to be capable of affording very great assistance,

both in personnel and materials, to the Government of their respective countries whenever they become engaged in war. The action of the National Aid Societies is voluntary, but is guided and restrained by regulations approved by the War Ministries, so that their members may work in harmony with the regular services for the welfare of their sick and wounded countrymen. They as much form part of the military medical system for meeting the hospital exigencies of war, as the volunteer combatant forces in England do with regard to the fighting arrangements for resisting invasion. Their official relations to the military authorities give the members of these societies a title to the privileges conferred by the Geneva Convention. There is nominally a similar society in England, but it has never yet had any official connection with the War Department, is not bound by any exterior authority, while its organisation has been chiefly adapted for carrying help from benevolent motives to contending armies abroad. Its personnel would not, under any circumstances, be entitled to claim the privileges of the Geneva Convention, as it is not included in the official military establishments to which alone the Convention refers. It is not necessary, therefore, to refer further to this society in the present work, which deals principally with the assistance that may be calculated upon for the wounded of our own armies.

Examples of army hospitals in time of war.—One or two illustrations will, perhaps, serve further to explain the nature of each of the various hospital establishments which have now been described. Let the last war in China in 1860 be taken as an example. At Hong Kong and its dependencies were the *principal general hospital* and *subsidiary hospitals*, where the sick and weakly were left on the expeditionary force starting northwards, and to which invalids were sent from the force which was operating in the field. An *intermediate hospital* was established in Talien-Wan Bay, where the force made its rendezvous before landing on the north coast near the mouth of the Peiho. The hospital ships in the mouth of the Peiho river afterwards formed the *second line of intermediate hospitals*; and when the troops moved to Pekin, a *third line of intermediate hospital establishments* was formed at Tien-tsin. The *field-hospitals* were with the army itself. Or, taking the Crimean expedition as an example, the *principal general hospital* at the base of operations was at Scutari, to which other stationary hospitals at Abydos, Smyrna, and Renkioi were successively added; the *intermediate hospitals* were those at Balaklava, and at the monastery, in the Crimea itself; while the *field-hospitals* were the divisional and regimental hospitals within the limits of the camp and immediately before the besieged town, as well as the occasional flying hospitals established in the ravines between the camps of the allies and the fortress. The sick and wounded were removed by ambulance trains, consisting either of

wheeled transport or mule conveyances, and part of the time by railway, from the field-hospitals to the intermediate hospitals; from the latter by hospital transports to the principal general hospital at the base; and from this again by hospital transports to the general invalid hospitals in England.

During the late war in France the arrangements were slightly different from those which have just been described, because the war was waged between two adjoining nations without an ocean intervening. The principal general hospital of the Germans was, therefore, established in a convenient position near the frontier, on the main line along which the troops were concentrated towards France, viz., at Mannheim. As the armies advanced, intermediate hospitals became established, first at Saarbrück, and subsequently at various points along the lines of military operations. As the principal general hospital at Mannheim became speedily filled after the early battles, other general hospitals were opened. At the same time, as circumstances permitted, the hospitals at Mannheim were relieved from time to time of their accumulated patients. These patients were collected in groups and sent in different directions, according to their nationalities; if Bavarians, they were evacuated upon Munich; if Saxons, upon Dresden; and so on. Here railways took the place of the hospital ships described as having been employed for the conveyance of the disabled invalids from the hospital at the base of operations at Scutari to England. As the armies advanced still further into France, and the sick and wounded increased in numbers, while the general hospitals near the frontiers were largely occupied by patients, it was found more convenient, in many instances, to send large convoys of wounded men from the field and intermediate hospitals by railway ambulance trains to permanent hospitals at further distances off in Germany, without any protracted halts at the general hospitals on the frontier. In some instances these journeys were of great length, as from Paris to Breslau or Königsberg. Lastly, the field-hospitals, or those moving with the troops, consisted of the field and dressing stations constituted by the regimental establishments and the *Sanitäts detachements*, and of the *Feld lazarethe*.

CHAPTER II.

ARMY HOSPITAL ADMINISTRATION.

Hospital administration for general service in the field.—In considering the distribution of the various medical establishments to be employed in time of war, already described, and the manner of administering the professional duties which devolve on the surgical

staff in connection with them, it is convenient to make a division of the subject in accordance with the surgical necessities which occur within particular parts of the sphere of military operations, and also with those which arise at different periods of time, in respect to the condition of the wounded. Usually a theatre of warfare, when the military operations assume an extended character, may be regarded as divided into three zones of surgical service, each comprehending a certain number of lines, or stations, of help. The first zone of service includes the space between the place of fighting itself and the line of the movable field-hospitals, and includes these establishments. The second zone includes the space between the movable field-hospitals and the general hospital at the base, or that occupied by the intermediate hospitals. The third zone comprehends all behind the theatre of active military operations, including the principal general hospital at the base of operations, up to the permanent hospitals in the native country to which the troops belong.

Subdivisions of surgical service in time of war.—Owing to the insular character of Great Britain the third zone of surgical service in the case of a British Army operating abroad becomes practically divided into three distinct and separate lines of assistance—viz., (*a*) the line of stationary hospitals at the base of operations; (*b*) the sea-transport homewards; and (*c*) that of the permanent hospitals at home. Each of these services, those of the three lines of the third zone as well as the two zones of the sphere of active operations, must be separately considered by those whose duty it is to make the necessary provision for the wants of the sick and wounded of the army.

The surgical help given during the transport of the wounded from the front to the rear of these several zones should be so arranged as to belong specially to the particular zone within which the removals take place; in fact, to be independent one of another as far as practicable. A special establishment for each zone, arranged in definite proportion to the amount of need, will not interfere with interchanges of the personnel, if circumstances render them desirable, so long as the numbers determined upon for each establishment are maintained.

Summing up the arrangement, then, the following is the disposition of the surgical wants which have to be specially provided for in time of war in the British service:—Those of the 1*st zone*, or the space from the place of conflict to the movable field-hospitals, inclusive of the latter; those of the 2*nd zone*, or the space occupied by the intermediate hospitals down to the base of operations; those of the 3*rd zone*, including (*a*) the space occupied by the fixed hospitals at the base; (*b*) that of the sea transport homewards; and (*c*) that of the permanent hospitals in England.

The mode of administering the surgical duties in the first of

these three zones will alone be considered in the present chapter. The administrative duties of the intermediate hospitals approximate to those of the general hospital at the base of operations, although they resemble the movable field-hospitals in their establishment and equipment. The administration of the general hospital at the base resembles that of a permanent general hospital in England. Instructions on the manner of conducting the duties in these hospitals constitute a regular part of army regulations. The same remark applies to the manner of conducting the surgical duties in hospital ships.

When the manner of attending to the first wants of the wounded from a field of action to the field-hospitals has been considered, it will be necessary, secondly, to glance at the plans of surgical administration for meeting the requirements of wounded men in some few military operations of a special character.

Administration from the fighting line to the field-hospitals.—The responsibilities which devolve on the medical officers of an army on the occasion of battle are very onerous. The safety of the lives of many wounded men, and the future condition of many of those whose lives are preserved, depend to such a large extent on the manner in which the surgical duties are discharged, that it becomes most important to determine the principles on which they may be best conducted. It is not possible to lay down strict and absolute rules of conduct for meeting the wants of the wounded. The circumstances under which battles begin, and under which they are carried on, as well as their results, are too various, and the changes which occur too sudden and too unexpected in their nature, for precision to be obtained in this respect. But if sound principles of action be established for meeting the most pressing necessities which usually occur on such occasions, these principles, if they are applied with judgment and intelligence, will generally meet the requirements of the wounded, however special the circumstances of an engagement may be, in the most effective way that is practicable.

The order of service to be performed in the first zone of surgical assistance will be, as before indicated: (1) to pick up the wounded, (2) to attend to wants of extreme urgency, (3) to carry them to the dressing stations, (4) to apply primary dressings, (5) to remove the patients when temporarily dressed to the field-hospitals, and (6) to supply definite hospital treatment. As the first part of this service must be rendered under fire and at much personal risk, only steady, active, trained bearers can be depended upon to perform it.

Surgical preparations at the commencement of action.—In whatever way a battle may be brought about, as soon as the attacking troops quit the close order in which they will have been previously marching, and begin to deploy and to form

an extended front, the surgeons attached to regiments, acting under directions from the chief divisional surgeon, and the men of the regiment appointed to act as assistant bearers of wounded, should fall to the rear—if they have not already become occupied through some of the troops being wounded by random shot while advancing in column—and should at once prepare for their respective duties. A bearer company, or advanced section of one, must also without delay get ready for its special work. At the same time, suitable positions should be sought for in rear of all the troops for the field-hospitals, some of which must be unpacked and got ready for the reception of the wounded. Regimental stations of help will probably have to be established in the first instance, some of the surgeons attached to the regiments working them with such means as they have at hand. The regimental bearers will get their stretchers from the carts, depositing their knapsacks, fire-arms, and accoutrements in them instead, and at once proceed to carry the wounded to a dressing station. If a bât animal be employed for carrying the stretchers, as would be the case in mountain warfare, the regimental men who are acting as bearers must deposit their arms at the dressing station with those of the wounded they may bring there. The arms will be taken charge of by an officer of orderlies of the bearer company.

One of the regimental surgeons at least should be told off to remain in the immediate rear of the fighting line of each brigade, ready to attend to cases of extremely urgent need, such as the arrest of dangerous hæmorrhage, and also to forward the continued removal of the wounded, the other surgeons being detached to help at the dressing stations. If the regiments be spread out in very extended order, it may be necessary for a surgeon to remain in rear of the fighting line of each regiment. The divisional deputy surgeon-general is responsible for such points of duty being attended to.

The preparation of the bearer company consists in distributing the water bottles, dressing bags, and stretchers to the bearers; in getting the conveyances ready for the carriage of the wounded; in establishing the dressing station or stations—at once indicating their positions by the flags supplied for the purpose—and in unpacking the articles of surgical equipment likely to be required at them; in pitching an operating tent; and heating water for tea or other restoratives. The men of the corps, when equipped, are ordered to their respective posts; some with their stretchers to the rear of the troops, and some to the dressing stations. The wheeled vehicles move to the places indicated as the first transfer stations, ready to remove the wounded to the dressing stations. Orders should be sent for the second line of ambulance conveyances to move to the front as speedily as possible.

The preparation of the field-hospitals consists in unpacking

and getting everything ready for the reception of patients; for the performance of surgical operations; for the application of definitive dressings; for the administration of food; and in making provision for all other probable needs of the wounded.

The field inspector, acting under the directions of the principal medical officer of the force, will have to see that the preparations just mentioned are properly made all over the field, and will watch that the service is regularly executed afterwards. The divisional deputy surgeon-general will advise with the surgeon-major in charge of the bearer company as to the position of the transfer and dressing station of the division; with the surgeons-major in charge of the field-hospitals as to their position; will see that the communications between them are properly maintained; and will personally supervise the performance of the whole of the duties of the first zone of assistance. If the deputy surgeon-general from any cause does not give the necessary orders on these subjects, the officers in charge of the bearer company and field-hospitals must arrange the positions on their own responsibility.

Early casualties.—Casualties may be expected to occur on the advance of troops towards an enemy, before they have assumed an attacking formation. They may happen at such a distance from the place where the fire of the skirmishing line commences, as to be outside the dressing station line after the troops have moved further forward. Such cases may have to be attended to at first by some of the surgeons attached to regiments, but should be as speedily as possible transferred to some of the staff of the bearer company, so as to set the regimental surgeons free for returning to their regiments. The bearer company will arrange for the removal of the wounded men to the field-hospitals. If, however, these casualties have not occurred at too great a distance from the front, cases occurring as the troops advance may be brought to the same spot, and, other circumstances rendering the place suitable, the bearer company may establish it at once as one of the dressing stations for the division to which the company belongs. The regimental surgeon should make every effort to keep up with the regiment to which he is attached while it is in movement.

Help-stations should be plainly indicated.—As soon as an action has become general and the successive help-stations have been established, their positions should be indicated as plainly as possible. Provision has been made for this purpose, both for the field-hospitals and for the dressing stations. As regards the dressing stations, it must never be forgotten that changes in the positions of the combatants may, at any moment, render changes in their positions necessary, and that, therefore, not only the personnel, but also the vehicles and their contents, should be kept as far as practicable in a state of readiness for a sudden move.

Difficulties in administration due to changes in fire-arms.—All

must admit that the changes in tactics resulting from the alterations made of late years in military weapons, especially from the introduction of breechloading rifles, have greatly increased the difficulties in the way of giving adequate early attention to the wounded on certain parts of fields of battle. The great disproportion in the losses among the troops at different parts of a field of action in modern warfare, and especially the excessive numbers that fall wounded on certain portions of the ground within brief periods of time, create special difficulties in surgical administration. The great lateral extent, too, now generally taken by the troops in front, and the whole formation of the 'fighting line,' are other impediments to early surgical assistance. Instead of the comparatively compact column formations to which foreign armies used to adhere under ordinary circumstances, and of the two-deep line formations of the British army, the tactics of the present day tend to the dispersion of flights of independent skirmishers in constant movement over a wide and extended area,—the men, for the time being, acting almost individually, either concealing themselves for the moment under any available shelter, or running forward, or extending outwards, as the case may be. This body of skirmishers is backed by a supporting line of troops at a certain distance behind them, as this, again, is by a third line at a still greater distance: all, however, acting as one body of troops under one direction, and forming the fighting line. When any of the skirmishers fall badly hit under these circumstances they cannot be got at, or, at least, cannot be got at until the troops, of which the skirmishers have been in advance, have passed up to the ground which the skirmishers had before occupied. Evidently, therefore, if they are unable to make their own way to the rear, the men of the skirmishing line who are wounded must remain where they fall, or under any shelter they may be able to reach, until the ground has become clear through the advance or other movements of the troops. It would be folly to subject the lives of men to the extreme risks to which they would be exposed in an attempt to remove wounded skirmishers while still under the fire of the enemy, even if there were not other objections, which there are, to making the attempt.

Successive stages of surgical help.—But many wounded men, especially those among the main bodies of fighting troops, are not thus out of reach during an action. To these every help must be given that is practicable. When the several help-stations are in working order it can be afforded in the following way; assuming that the system of help, which has been sketched out in the foregoing remarks, is duly carried out. The wounded that can be got at are picked up by the regimental bearers, or by some of the bearer company, and placed on stretchers. They are then carried for inspection by the surgeon at the first help-station, if

he be at a convenient distance and position; or, if it would take up too much time to do so, are carried direct to one of the transfer stations. The bearers, on reaching this station, lay them down on the stretchers on which they have been brought from the field, take the stretchers from the wagons, or other vacant stretchers placed ready for the purpose by the bearer company, and return to the troops engaged for more wounded. A surgeon should be at the transfer station, or a steady N. C. officer of the Army Hospital Corps, to superintend the transfers and to afford any help that may appear to be very urgently needed. They are then removed in the ambulance wagons to one of the appointed dressing stations.

On arrival at the dressing station the wounded will be successively examined by the senior surgeon present, or by a surgeon told off for the purpose, and disposed of according to the nature of their injuries. Those requiring surgical operations, as amputation, ligature of arteries, adjustment of fractured bones, should be placed in one category; those only requiring simple dressings in another. Mortally wounded men should be placed where they will be least disturbed, and their condition rendered as easy as possible. The surgical duties should be distributed among the staff and attendants in such a way as to ensure the duties being done systematically, efficiently, and without any delay. The surgeon who receives the cases as they arrive, ought to indicate those which require the earliest attention and give the necessary directions accordingly, as well as those which will allow of the dressing being deferred with least harm. As soon as the wounded have received whatever preliminary operative interference, dressings, or other surgical attention they need, their specification tallies (see equipment, page 497) are filled up, and those who are unable to march are sent on in the ambulance wagons to the field-hospital station. The slightly wounded are sent on to a field-hospital on foot, or by any store-transport or other conveyances that may be available for the purpose. If no preliminary attention be required although the men are badly wounded, they should be moved on in the same ambulance wagons in which they have been brought, without any delay at the dressing station beyond what has been necessary for examination. When the wounded are given over to the field-hospital establishment, the men of the bearer company, and the vehicles, should return as fast as practicable to the transport station for more patients. Active supervision on the part of the transport officer who commands the detachment of the Army Service Corps attached to the bearer company, and of the officer of orderlies in charge of the bearers, will always be required to ensure the conveyance of the wounded from the field of action to the dressing stations and field-hospitals, and the return of the men and vehicles, being maintained without interruption.

If the army be advancing steadily, and there is every prospect of the ground it has gained being retained, not only the surgeons occupied in the immediate rear of the combatants should move forward with the troops, but, as far as practicable, those at the transfer and dressing stations. If there are wounded waiting for attention or removal at these stations, they should be dressed and dispatched to the field-hospitals with all possible speed, to enable the stations to be advanced towards the combatants. If the number of wounded requiring attention at the dressing station do not admit of an advance taking place, some of the surgeons and attendants must be detached, the necessary materials pushed forward, and a fresh dressing station be established in a suitable position. This, as well as all other details of movement and action of the bearer company, must be arranged by the surgeon-major in charge of the company, of course subject to the general direction of the divisional authorities. If, however, in case of an advance, the stations could only be placed in some objectionable position, they must perforce remain where they have been already working, notwithstanding that the time occupied in the transport of the wounded from the field of battle will be proportionately increased before they can be brought to the dressing stations for their wounds to be attended to. It is one of the advantages of independent field-hospitals that one or more can be advanced and opened without difficulty, in case the military movements make it desirable to do so. Thus the necessary hospital attention and accommodation can always be maintained for the wounded, if the requisite number of field-hospitals is with the force.

No accumulation of wounded men at a dressing station should be permitted to take place whenever it can be avoided. The removals to the rear should be as continuous as the arrivals. If transport cannot be obtained for the purpose, and it is getting late, it may be necessary to keep some of the wounded for the night; but, under any circumstances, the dressing station must be cleared of all wounded the day after an action. Each bearer company should be free and ready to move as soon as the body of troops to which it is attached.

If the engagement should happen to progress unfavourably, the army will probably have to retire—perhaps to retreat altogether; and, as the issue of events in war is always more or less uncertain, it is necessary to be prepared beforehand with a general plan of conduct to meet each variation in circumstances, as it arises, in the best way practicable. It is the uncertainty just referred to that makes it an object of such extreme importance continually to pass on from the front to the rear, as rapidly as possible, all wounded men that are able to bear removal. If this rule be not attended to, and a retrograde movement have to take place suddenly, confusion will certainly occur; and many lives must be sacrificed, which might, perhaps, have been saved under better arrangements.

If the army should have to retreat, all the wounded at the transfer and dressing stations that can be conveyed should be brought away. Both stations should be directed towards the nearest field-hospital. If the troops should fall back as far as the field-hospital itself, no attempt should be made to move this establishment, which could only be effected with great positive injury to very many of the wounded in it. It should remain stationary, part of the surgical staff and surgical equipment being told off to stay with it. The wounded and the staff necessary for attending to them will be protected by the articles of the Geneva Convention. At the same time all ambulance vehicles, both for sick and store transport, that appear capable of effecting a retreat with the troops should make every effort to do so, in order that their services may remain immediately available for fresh wounded among them.

None of these arrangements should ever be made by the surgeons-major in charge of the bearer companies or field-hospitals independently, unless extremely urgent circumstances compel them to do so. They should wait for instructions from the field-inspector or divisional surgeon-general, whose special functions are to keep a watchful eye on the progress of events, and the necessities of the various hospital establishments under their general direction.

When an action is concluded, a systematic search of the battle field and its vicinity should be made for any wounded men that may be lying on the ground. A certain number of medical officers and officers of orderlies, with a body of bearers under their orders, and a supply of ambulance wagons, should proceed by the shortest way to the scene of action. The bearers should be divided into squads under non-commissioned officers, and should thoroughly examine not only the open ground, but also any woods, ruins, ditches, or other places of shelter there may be in the neighbourhood. The importance of this duty, and the points to be attended to in discharging it, have been elsewhere referred to.

Hospital administration for particular services in the field.—The system of army medical administration which appears to be best calculated to ensure due attention to the necessities of the wounded, so far as general service in the field is concerned, having been sketched out, the administration for certain special military exigencies remains to be noticed. They can only be very briefly adverted to. The needful arrangements when a force is ordered to embark with the intention of effecting a landing on an enemy's coast, when a force is on the march, on the approach of a general action, when troops are engaged in siege operations, and on the occurrence of a home invasion, will be successively glanced at.

Administrative arrangements on a force starting from England. Before an army starts on a hostile expedition, the surgical staff, and the surgical establishments of the force, with their equipments, will have been completed according to the principles previously ex-

plained. The coast upon which the troops are destined to land may be close at hand or distant. If near, as across a channel, the troops will probably be carried on the decks of steamers, or in open vessels towed by them. If the coast be distant, as across an ocean, the troops will be sent in regular transports, and probably land in the first instance on some colonial dependency, or in the territory of some friendly power, at no great distance from the point to be attacked. The military object of this preliminary landing is that the whole force may be assembled and marshalled together, and that the final arrangements for moving in concert may be settled. It will be convenient to consider the surgical proceedings in case of the troops having to land in a distant country, as they will include most of the arrangements for landing on a coast near at hand.

Although the duties of the medical department connected with the preservation of the health of the troops are not described here, it must not be supposed that their importance is underrated. Nothing can be more essential, even as regards the recovery of men who suffer from gunshot wounds in the field, than that their constitutional health shall be maintained in the soundest state practicable up to the time that they happen to meet with their injuries. The fitness of transports for the reception of the bodies of troops to be carried in them, and the manner in which hygienic regulations are conducted while the men are on board, as well as while they are on service in the field, will all have an important influence on the results of the wounds and injuries to which they may afterwards be subjected. But definite regulations concerning these matters already exist, and need not be repeated in this work.[11]

When an expeditionary force has been collected at a place of rendezvous and the final preparations for its embarkation have been completed, detailed orders are usually issued for the information of every corps and department concerned in it. These orders include instructions regarding the positions and duties of all the officers and men in the expedition. The orders for the embarkation of the divisional and brigade medical officers will probably direct them to proceed on the transports detailed for the general staff of the division or brigade to which they are attached; the principal medical officer of the army, field inspector, and sanitary inspector, to proceed with the head-quarters staff; the bearer company and field-hospital establishments, to embark on the transports which carry their respective stores and equipment. All the supernumerary medical officers will probably take passage in the hospital ships; while the medical officers attached to regiments will accompany their respective corps.

It is the duty of each medical officer in charge of a corps or detachment of troops, on embarking, to send to the deputy surgeon-

general of his division a *numerical* return of the officers and men embarked, and a *nominal* return of any sick that may be left behind, specifying their ailments, and to whose medical care or to what hospital they have been transferred. The returns thus furnished by the medical officers with the troops are tabulated in general returns, and are forwarded through the field inspector to the surgeon-general. It is only by these means that the principal surgeon-general of the army can learn correctly the distribution of the troops composing the force, and furnish the General Commanding with information respecting the changes from disease and injury among them. In like manner, on completion of the voyage, a return has to be furnished, showing any changes that may have taken place from sickness or injuries during it.

Arrangements when landing in an enemy's country.—On the arrival of the force at its place of final destination, the disembarkation and landing of the troops may be opposed by an enemy in front; or it may be unopposed, as when a landing is effected at some distance from a place where the enemy has taken up a position of defence.

Should the landing appear to be likely to be resisted, it becomes the duty of the medical officers, each in his respective sphere, to make preparations for the care of the wounded they may have to attend to. Surgeons attached to particular corps should have with them the orderlies who carry the Medical Field Companions, and some dressings ready for use. Everything should be got ready on the hospital ships for receiving wounded, and for the surgical operations which may have to be performed. Care should be taken that the boats appointed to carry the wounded from the beach to the hospital ships, are furnished with an ample supply of fresh water and tin vessels for drinking purposes. There should also be lanterns and matches for light in case the wounded have to be conveyed at night time. Some ships' cots will also be useful as conveyances. If practicable, large boats should be obtained for this work, and they should be furnished with mattresses on which to place the wounded, and some blankets as coverings.

If the landing be secured, the removal of the wounded to the hospital ships may be managed with comparative ease; but, in case of the attacking force meeting with a repulse, and being compelled to return to the ships, the duty must always be a difficult one. The wounded will have to be brought off with the least possible delay under cover of the guns of the ships, and the utmost presence of mind on the part of the medical officers will be necessary to conduct the operation with due regard to the necessities of the officers and men who have been seriously injured. If, however, the enemy be driven away and the landing of the troops secured, there will be no difficulty in establishing temporary dressing stations on or near the shore. Two objects should be kept in view in selecting the positions of the dressing stations on

such occasions; one, facility of bringing the wounded to them from the place of fighting, the other, facility, after dressing, of carrying them to the boats for removal to the hospital ships.

The duty of collecting and dressing the wounded, and removing them to the boats, will principally devolve on the staff of the bearer companies. Some of the staff destined for service in the intermediate hospitals, and as many of the hospital ship staff as can be spared, may be rendered useful in attending to the wounded during their conveyance in the boats to the hospital ships. It is not likely that further assistance will be required; but, if it be, some of the naval surgical staff will probably be available for it. The wounded should be got on board the hospital ships as speedily as possible. The troops, after effecting the landing, will probably lose no time in moving forward and taking up a position at some distance from the beach, and the battalion medical officers will be required to be with them. If the landing be thoroughly secured, and so decisive a victory obtained over the enemy that they retire altogether, then all the regulated surgical equipment should be sent on shore. The whole of the bearer and field-hospital establishments for the first zone of surgical service should be completed and got in order without delay, so as to be able to join the army, and be ready to move with it, whenever the order for an advance is issued.

As soon as possible after the engagement, as on all similar occasions, *returns of casualties* should be made out and dispatched to the principal medical officers of divisions by all medical officers attached to bodies of troops. The casualty return consists of a nominal roll of all the officers, non-commissioned officers, and men of the particular corps concerned who have been injured, with a terse description of the kind of injury received, and its degree of severity. Similar returns should be furnished from the hospital ships to which the wounded men have been taken, to check and supplement those furnished by medical officers attached to particular corps.

If it be intended to maintain a footing at the place of landing, and to keep up communication between it and the army, an intermediate hospital with its regular staff may be at once established there. If any suitable buildings are available, they should be at once secured, if possible, for the hospital. As soon as this is achieved, if there are only a few wounded on the hospital ships, and the ships are in an open roadstead, the wounded should be brought ashore to the hospital, in order to avoid the inconveniences which they might suffer in case of stormy weather. If, however, a hospital ship be full of sick and wounded, it should be dispatched to the general hospital at the base of operations from which the expeditionary army started, with orders to return immediately after transferring the patients to that establishment. Every care should be taken to enforce the speedy return of a hospital ship when it is

sent away; circumstances may lead to the intermediate hospital having to be abandoned, or an increase in the number of wounded may occur suddenly from some fresh engagement with the enemy. The army having secured its footing on shore, the troops may either remain for a time to fortify their position, especially if the landing has been effected near a town; or a brigade or division of troops may be left for this purpose, while the main body of the army moves forward. The medical officers who remain with the troops left behind under such circumstances will always find the exercise of their hygienic functions one of the most important, if not the most important, part of the duties which devolve on them.

On this, and, indeed, on all occasions when troops remain stationary for a time during a period of warfare, wherever a general hospital is established, surgeons should never let any opportunity be lost that may offer itself of practising the principal operations of surgery on the dead body. Nothing passes from the mind so readily as details of anatomy, or from the hand as dexterity in the performance of intricate surgical operations; nothing is so difficult, under ordinary circumstances, for surgeons in the army to obtain as opportunities of refreshing their knowledge, and of exercising their abilities by practice, in this branch of their profession; and yet how essentially necessary this knowledge and dexterity become on the day of battle! The preservation of the lives of many of the wounded, and the future welfare of those among them who survive, will materially depend upon the practice of performing surgical operations on the dead body being followed, much more so than seems to be generally understood, or, at least, acknowledged. Moreover, the information and dexterity acquired by such means will be sure to prove a source of satisfaction to the surgeons themselves when they have to perform similar operations on the field or in the field-hospitals; and, at any rate, will save them from the mortification, elsewhere noticed, of being restricted from acting in this branch of their profession. It will always be better for such exercises to be systematically carried out under the supervision of a competent and experienced senior surgeon, than for them to be resorted to by surgeons singly and independently. The staff of the bearer companies and men of the Army Hospital Corps with the field-hospitals should at the same time be regularly drilled by the officer in charge in unpacking and loading quickly their respective equipment vehicles; in putting up, striking, and repacking the tents; in familiarising themselves with the contents of the surgery and pharmacy wagons, and their arrangement. They should also be practised in the various modes of lifting up wounded men according to the nature and situation of their injuries, placing and carrying them upon stretchers, applying provisional dressings and tourniquets, and, in short, in all duties bearing on the care

and handling of wounded soldiers which they may have to perform in the field. Although they may have been already instructed in these duties, frequent practice is essential for that steady and skilful execution of them which is of such extreme importance in the midst of the exciting circumstances under which they have to be practically applied.

Arrangements with troops on the march in time of war.—The army, or the main body of the army, which has effected its landing will probably be soon ordered to advance into the country, and this leads to the propriety of considering some of the arrangements necessary before marching, and during the march.

The principal subjects to be attended to on occasions of marches have reference to the preservation of the health and efficiency of the troops. As with regard to other sanitary regulations, so these are not attempted to be described in this work, in which the arrangements for the best treatment of the wounds and injuries liable to occur, and those most conducive to the welfare of the wounded men themselves, are mainly kept in view.

Before a march commences, particularly if the troops have been encamped near a town, a health inspection should be made very carefully by each surgeon in medical charge; and all men who labour under any physical ailment, or who appear from any cause incapable of continued marching, should be separated for the observation of the divisional inspecting surgeon, with a view to their being left behind for treatment. No ailing men should be taken on; they will only lead to difficulties in respect to transport, and the ambulance vehicles should be reserved for those who may casually become disabled during the march. Nominal returns of men left behind have to be sent in to the commanding officer, and to the principal medical officer, through the usual channels. All hospital transport and equipment should also be carefully inspected, and, if any defects or deficiencies are noticed, they should be remedied as far as practicable before the march commences.

The positions of the bearer company and field-hospital establishments on the line of march have been already mentioned. Under ordinary circumstances the treatment of men falling sick or hurt will, in the first instance, be given by the bearer company; and, if it be necessary to remove them, they will be carried by some of the ambulance conveyances of the 2nd line to the most advanced hospital open in rear.

Before starting on the march, it is a good rule for regimental surgeons to provide themselves with small pieces of paper, on each of which is written the date, signature, and the words 'Permitted to fall out,' or some similar remark, to show that the bearers of such papers have been medically inspected. When a man is disabled from marching by illness or any other cause, he must obtain the permission of his captain to leave the ranks. A non-commis-

sioned officer will usually bring him to a surgeon, who administers a little medicine, if that is all that is required, or, should the man be found unable to proceed, gives him one of the papers just referred to, or *sick tickets* as they have been called. The man then waits by the side of the road until one of the ambulance wagons of the bearer company with a vacant place comes up, and the sick ticket is the authority for his being carried upon it. If by chance no place should be found in the ambulance wagons of the 1st line, and he is unable to march slowly on, he must wait till one of the 2nd line is available. Such patients, according to the nature of their cases, will either be discharged from duty in the ranks, or transferred to the care of that portion of the medical establishment which is under the immediate direction of the officer in charge of the line of communication between the army and its base of operations.

The names of all men received and carried in the ambulance wagons should be properly recorded. They should appear in the daily state of sick, even though they may be well enough to resume duty on their arrival at the halting-place, and to proceed on foot the next morning. Such cases will be recorded as 'admitted' and 'discharged' on one and the same date. An ambulance wagon, while moving with troops on a line of march, should be regarded to all intents and purposes as part of a movable hospital. Its true and sole application to the objects for which it has been provided should be religiously maintained: and, that it has been so appropriated, should admit of demonstration by reference to the daily hospital returns. It should never be employed for the carriage of stores, or of any persons or articles other than those for which it has been specially designed and constructed. When unoccupied by sick and wounded men, it should be kept vacant and ready for their reception, on the same principle that the wards of an established hospital are retained, fully equipped for use, when there are no patients in them. But, unless the most stringent orders on this subject are issued by the highest authorities, and steps taken to insure implicit obedience to them from all concerned, experience has sufficiently shown that these vehicles will not unfrequently be diverted from their intended purpose; and sometimes will meet with damage, affecting their subsequent fitness for service as a consequence.

If the army is marching without tents, pickets are posted as a matter of course when the troops bivouac for the night. As it must almost always be uncertain whether an attack may not be made by the enemy, the officer in charge of the bearer company should be acquainted with the readiest approach to these pickets, in case the need should arise for removing and attending to wounded. If the pickets are very strong, a surgeon and a certain number of bearers with stretchers should be posted with them.

One of the last things at night that each executive medical officer with troops should do, is to ascertain exactly the position of his personal case of instruments, and of his orderly with the Medical Field Companion, so that he may be able to have recourse to them in a moment, even in the dark, in case of a sudden alarm.

It is presumed in the foregoing sketch that the communications of the army are kept open with the base from which the march commenced. In modern warfare it is understood that the maintenance of the lines of communication, and of all departmental movements along it, is to be placed under the command of a special officer with a competent staff to assist him. It will become the duty of the principal medical officer on the staff of this commanding officer, to submit to him for approval the places along the lines of communication which may appear most suitable for the establishment of intermediate hospitals, the arrangements that may appear desirable for the transport of the sick and wounded to them, for their removal by railway ambulance trains to distant hospitals, for bringing convalescents up to the front, and all other medical concerns behind the main body of the army operating in the field.

If a force be moving independently, all who become disabled must of course be carried with it, unless, when moving near a coast, there may happen to be an occasional opportunity of removing them to hospital ships or to other vessels.

Administrative arrangements on the approach of a general action. If an enemy is about to be met in force, and it is sufficiently evident that a general action will be fought, the field-hospitals, every available surgeon, and all the additional transport that can be got together for the removal of the wounded, should be brought up as near to the front as practicable. Perhaps there will have been time to allow of many of the general supplies of the army being placed sufficiently near for reach without employing the usual store transport for their distribution, and, in this case, the store conveyances can be turned to account for removing the slightly wounded men to the rear. The regulation transport taken with the force at starting will also probably have been increased by carts and animals requisitioned from the inhabitants during the march, and these will afford a further supply of carriage that can be used for the same purpose.

If the army has been marching independently, only the surgeons who have accompanied it can be present; unless, as happened at the battle of the Alma, being near the coast, additional surgical assistance can be obtained from friendly vessels of war. In such a case the services of the naval surgeons who may be landed will be turned to best account if they are instructed to act for the time under the directions of the principal medical officer of the army, in order that he may dispose of them where they are most required. If, instead of marching independently, communication has been

kept up with a base of operations, and the prospect of a battle being fought has become apparent in time to afford the opportunity to give the necessary orders, every medical officer, not actually required in the hospitals in rear, should be sent forward, as a temporary measure, to the front. They will not only be useful for assisting in the field surgical duties, but will be required for accompanying the wounded who may have to be sent to the rear afterwards. So also, for similar reasons, all hospital attendants that can be spared for a short time from the intermediate hospitals should be sent on for duty to the front.

Now is the time, when a great battle is about to occur, that surgeons will most thoroughly appreciate the advantages of having properly prepared themselves for meeting their professional responsibilities by real and honest practical study, and by having made themselves acquainted with all the details of the surgical appliances at their disposal; just as it is the time when those who have not done so will feel most keenly the painful situation in which they have become placed from their previous neglect. Shortly after a battle has commenced, surgeons usually find themselves surrounded by so many wounded men, all of whom urgently require assistance, that it is impossible for them to do what they have to do as quickly as they desire, however unceasing may be their exertions, much less to find time for deliberating on what ought to be done. Self-possession, and decision without delay, grounded upon professional knowledge, are essential for the adequate performance of the duties which devolve upon the surgeons on the occurrence of such a critical event as that of a general engagement.

The situations where help can best be afforded to wounded soldiers during the progress of an action and subsequently to it, and the arrangements best suited for ensuring that this help shall be systematically and speedily afforded, have been sufficiently indicated in describing the system of surgical administration for general service in the field.

Administrative arrangements during siege operations.—In considering the circumstances of siege operations, whether with reference to the duties of the medical staff within a besieged town or fortress, or to those of the staff with the besieging force outside, the study of the means of preventing sickness again assumes the place of first importance, even when to obtain successful results in the treatment of the wounded is the main object in view. Within the besieged place, these preventive measures chiefly consist in providing the necessary stores and varieties of food and in economising their distribution, but particularly in the most strict and regular attention to sanitary regulations; among the besiegers, preventive measures must be chiefly directed to counteracting the injurious effects of the harassing duties, hard labour, loss of rest at night, and exposure to weather, to which the troops are subjected

in the trenches. To describe the best mode of accomplishing these desirable results is the province of works on military hygiene. The remarks which follow will be limited to points connected with the special administrative arrangements for the hospital service, and for the treatment of the wounded, on occasions of sieges.

Arrangements inside a besieged place.—The provision of supplies for the hospitals should be specially considered. If the state of siege is likely to be of long duration, in addition to the usual hospital comforts and supplies, a stock of such articles as are likely to prove serviceable in warding off scorbutic, and allied, conditions of body, should be laid in freely. Sufficient stores of the remedies required for extensive burns, likely to result from explosions, or buildings set on fire by incendiary projectiles, should not be forgotten. If there is likely to be a want of water, the medical department should try and get a well sunk in the vicinity of the principal hospital while the men are strong and able: at the same time all means of collecting and storing rain water at the hospital should be carefully guarded.

In calculating the amount of medical and surgical stores which may be required under such circumstances, it is not enough to consider only the wants of the troops forming the garrison: the possible additional demands from a relieving force, should one get into the place besieged, must also be provided for. When the relieving forces of Generals Outram and Havelock made their way into Lucknow in September 1857, most of the regiments lost their medicines and surgical instruments during the advance through the hostile part of the city. They subsequently became almost wholly dependent on the stores of one regiment, the 32nd, for these important articles, and the stock of this regiment had become greatly reduced previously to the date named. The instruments were blunt and hardly fit to be used, the chloroform was expended, and the materials for dressing the wounded were exceedingly scanty. It should not be forgotten, also, when apportioning the medical staff to the troops in a place about to be besieged, that there will not be the means of replacing those who may fall sick, or who may die from disease or injury. An increase, proportional to the probable average number of casualties, should therefore be provided.

As soon as the siege has commenced, a regular rollster of all the medical officers should be kept for garrison duty, so as to distribute the surgical labour as evenly as possible. Two medical officers should always be on duty together, for mutual aid, and in case of accident to either. A dressing station should be fixed in some central position. Some of the inhabitants should be got to help the men of the Army Hospital Corps and bearers, in bringing the wounded to the dressing station and attending to their needs.

When the storming of a breach is expected, the medical officers, with men of the Army Hospital Corps and bearers, should assemble in any suitable place near at hand, ready to give assistance. If the storming be successful, they must fall back upon the hospital. If the attack be repulsed, a truce will probably be agreed to, when some of the medical officers should get down to the ditch, to superintend the removal of the wounded from it and from the glacis. No time should be lost in removing the wounded from their wretched position about the ditch and its vicinity. Lanterns should be used, if necessary, for continuing the search at night. The wounded of the besiegers, who may be lying about the works, should be given over to their own surgeons to avoid encumbering the hospitals within the besieged place; if once taken into the town, it is not likely that the commandant will allow them to return, lest they should give information injurious to the interests of the besieged.

Surgical arrangements with a besieging army.—If the besieging force is carrying on a regular siege—not merely investing the place with the intention of starving it into capitulation,—the labours of the medical officers are always very severe and incessant. Notwithstanding its communications are open, so that supplies of all kinds may be brought to the army, its sick and wounded quickly removed, and reinforcements brought up, the average amount of disease and mortality in a besieging force is usually greater than it is in the force besieged. This depends particularly on the unhygienic conditions to which besieging troops are usually exposed: and a most important part of the work of the medical department is to counteract the effects of this exposure, as far as practicable.

The steps to be taken for the surgical care and treatment of the wounded will be much the same as those already described for an army engaged in action in the field. Similar arrangements are required for giving primary attention to the patients in the trenches, for their removal from them, for the provisional treatment of their injuries, and for their conveyance to the field-hospitals. As the field-hospitals are, however, less likely to require removal, it is only as they become encumbered with many occupants, or when they are ordered to be cleared in anticipation of a sudden increase in the number of wounded from an intended attack, that the same urgent necessity exists of evacuating them upon the intermediate hospitals in rear as is experienced in open warfare.

The primary attention is usually given by a surgeon in as sheltered a part of the trenches as he can obtain, and the wounded men are then carried away under the shelter of the parapets on stretchers. Some have expressed doubt whether the risks to which the surgeons are exposed in the trenches are compensated by any advantages they can afford to the wounded in such a

hazardous position. Dr. Millingen, whose extended experience during the Peninsular wars gave great value to his opinions, has said that surgeons can be of little, or rather of no service, in this dangerous situation;[12] and that, instead, bearers should be stationed with their stretchers at such points of the parallels as the engineers may consider safest, and should at once carry off the wounded men to the field-hospitals for treatment. But there can be no doubt, from the experience of the siege of Sebastopol, that the surgeons in the trenches on that occasion were of essential service to the wounded; and, if shotproof protection in an appropriate part of the works be constructed for the medical officers, as was then done, and should always be done when practicable, no less for the preservation of the surgeons than for that of the wounded to whom they have to attend, as well as to admit of using a light at night, it can scarcely be otherwise than that their presence must prove of great service. The surgeon's position should be as near to the troops most exposed as engineering convenience will admit, but not so near as to be liable to be surrounded in case of a sortie and of the enemy getting within the works. It should also be as central as possible, to facilitate the approach of the bearers from both sides of the trenches.

When the assault has been determined upon, a proportion of medical officers should follow the troops, but should not quit the most advanced parallel of the works while the attack is proceeding. There will be ample occupation for them in attending to the wounded who are able to make their way back from the open ground in front, without needlessly exposing themselves to the severe fire to which the assaulting columns will probably be subjected. But if the storming be successful, they should hasten forward to the breach, or the parts of the enemy's works which have been escaladed, as soon as the firing has ceased, for the numerous wounded lying there, probably heaped one upon another, will most urgently require assistance. They should be accompanied by as many bearers as can be got with stretchers, and every effort should be made to get the wounded removed as quickly as possible to places where they can obtain shelter and surgical attention. If the assault be unsuccessful, then, as before mentioned when referring to the arrangements with the troops besieged, it must be hoped that a truce will be mutually agreed upon for the removal of the wounded, as well as for the burial of the dead.

Administrative arrangements in case of invasion.—The general principles on which the wounded would have to be dealt with in case of an enemy invading the home country will be much the same as those already described for a general action. A considerable amount of uncertainty must exist as to the part of the coast on which the enemy will try to effect a landing. Still certain parts are more likely to be selected for such a purpose than others,

and it becomes very important that the means of carrying all necessary surgical assistance to the neighbourhood of these points where an action might be fought, should be well considered and arranged. The positions of the fixed and intermediate hospitals, relatively to any part of the coast where an enemy could possibly effect a landing, and the means of conveying the wounded to them, ought to be thoroughly determined beforehand. The organisation of the bearer companies ought to enable them to meet the first wants of the wounded, and also those connected with their removal by road or railway to the hospitals. The field-hospital establishments should well answer the purposes of either primary or intermediate hospitals in any places suitable for placing them. Specific instructions should be prepared, and kept ready for issue on all points connected with these duties. The directions given on these heads should be marked with the greatest precision, for a misunderstanding might lead to clashing with other military arrangements, confusion, and even to disaster as regards the wounded. It is not to be forgotten that, in resisting an invasion, not only regular troops would be engaged, but militia forces, and volunteers, who cannot be expected to be familiar with many of the hospital and transport arrangements of the military service. The interests of the wounded require that there should be equal precision in the administrative arrangements and orders of the medical department of the army, as there usually is in those of the combatant branch for directing the movements of troops and of war matériel. The medical arrangements for the disposal of the men who are disabled can only be made with the approval of the combatant authorities, and in complete harmony with the general arrangements of the military service.

CHAPTER III.

HOSPITAL EQUIPMENT.

Preliminary remarks.—The equipment required for the care and treatment of the wounded in time of war consists of (*a*) the surgical, medical, ward, cooking, and table equipment—the whole being included under the general term 'hospital equipment;' and (*b*) the 'transport equipment'—this latter comprehending the store-transport vehicles, and the sick-transport conveyances. The principal articles composing the different descriptions of hospital equipment in the British service, and the vehicles or other means by which they are conveyed, will be described in the present chapter; the sick-transport equipment will be separately considered in the one succeeding.

The equipment of military hospitals varies materially in different countries as to the kinds of articles employed. In all armies it is very important that the equipment, both hospital and transport, which is selected for being taken into the field, shall be well chosen; for experience has shown that in proportion as it answers the purposes for which it is intended, so the number of grave surgical operations required to be performed on the wounded may be expected to be lessened, and the ratio of successful results to be increased when the nature or consequences of their wounds render such operations unavoidable.

The difficulties in the way of selecting the most appropriate equipment for field-hospitals are very great and numerous. Almost every variety of casualty has to be provided for; yet military necessities, and the limitations of space, confine the selection of articles to such as are very simple in character, moderate in cost, and readily portable. They must be capable of withstanding rough usage. They must not suffer from being carried about from place to place, or be easily injured by exposure to changes of temperature and varieties of weather. So many limitations and restrictions are practically met with in selecting hospital supplies for field use, that it becomes impossible to meet all the conflicting views that prevail among different surgeons on the subject, or to respond to all the demands that are made by them. The only practical plan is for definite scales of equipment and fixed descriptions of articles to be laid down—such as experience has shown to be best suited for meeting the common needs of service—and for surgeons to be required to conform to them; although it may be known beforehand that in some instances, should special circumstances arise, it will be easy to suggest articles which would be better suited to meet the wants of these particular occasions.

Difficulties of a somewhat similar nature occur in determining the forms and construction of the conveyances for the wounded. It would be comparatively easy to design appropriate sick-transport vehicles to meet any fixed conditions. But the conditions under which the vehicles are required for the transport of wounded soldiers in the field are in no respects fixed. The conveyances must be made suitable for moving over almost every kind and condition of ground, whether made roads or rough fields; for all kinds of weather; for use in winter as well as summer; they must be solid in construction to resist the severe shocks to which they will inevitably be subjected in campaigning, yet they must not be too heavy; they must themselves admit of being packed in a small space for stowage on board ship, yet must be firmly and securely put together; and they must be fit for carrying patients in a sitting position and lying down, and suffering from every kind of injury to which men can be subjected. If the surgeon states the wants from his own point of view, he is met on one side by necessities

from the combatant's point of view, and on the other by those which are bound up with the regulations of the military constructors. Both of these interfere more or less with the execution of the surgical requirements. Thus, in the end, all that can be hoped to be arrived at is the best pattern that can be obtained under a system of compromise: a conveyance so far adapted to the wants of the sick and wounded, as the conflicting circumstances which it is designed to meet, and military requirements, will allow.

Seeing, therefore, that all articles comprised in the equipment of field-hospitals have to be limited in quantity, and special in character and design, it becomes most important that the officers and men who will have to employ them in time of war should become familiar with them in time of peace: accustomed to handle and use them, and acquainted with all the purposes they are designed to subserve. Without this familiarity, the equipment provided by the Government on the starting of an expedition is not likely to be properly understood, at any rate in many of its details, and a want of knowledge of the proper use of one part of a contrivance will not unfrequently be the cause of the whole being thrown out of gear; some of the articles composing it will not improbably be altogether misapplied; and none of the equipment is likely to be so economically cared for, and maintained in order, as it ought to be.

Different classes of hospital equipment.—Supposing the different parts of the system for aiding the wounded in time of war to be organised on the principles which have been described in the previous chapters, the surgical equipment may conveniently be divided for consideration under the following heads: (1) the regimental equipment; (2) the bearer company equipment; (3) the field-hospital equipment; (4) the intermediate hospital equipment; (5) the stationary or general hospital equipment; (6) the equipment of hospital ships; and (7) the equipment of permanent hospitals.

The equipment of the first three divisions—the regimental, the bearer company, and field-hospital establishments—is principally concerned with the treatment of gunshot injuries, though it must also include the means of temporarily treating casual cases of sickness. The equipment of the intermediate hospitals, and of the general hospital at the base of operations, must be adapted to meet the requirements of men disabled by disease as much as of men disabled by wounds. This applies also to the equipment of hospital ships. The equipment of the fixed or permanent hospitals in the home country does not differ in war time from the equipment in time of peace. The articles of which it is composed and their numbers are to be found in the ordinary regulations of military hospitals.

Method of obtaining supplies of equipment.—It may be useful

to mention the mode in which supplies are obtained on troops taking the field, before describing the supplies themselves.

It was formerly the custom, and so remained up to the issue of the Revised Regulations for the Army Medical Department in 1859, for each medical officer in charge of a body of troops, on the commencement of a campaign, to make a written requisition for the hospital stores, medical comforts, tents and other equipment, which he supposed the sick and wounded of his corps would want in the field. When these requisitions were approved and signed by the principal medical officer, they were forwarded to the apothecary's, purveyors', commissariat, or quartermaster-general's department, according to the nature of the articles required. The officers of these departments complied with them or not, according to their ability to supply the articles asked for or otherwise. This plan was attended with much inconvenience, and often with waste. It requires no little experience and discrimination to select supplies for the field with due regard, on the one hand, to the relative utility of the various articles asked for; and, on the other, to the means of transport at command, and to the circumstances of the country and operations in which the troops are about to be engaged. Another ill result of the plan was that, although the articles asked for were such as would tend materially to the welfare of the sick or wounded, occasionally some of them would not be supplied because the departmental officer, to whose discretion compliance with the requisitions was left, might take a different view from the medical officer in regard to their necessity.

A similar arrangement existed for obtaining the means of transporting the hospital stores and equipment. Requisitions had to be made upon the quartermaster-general's department, or on the military train, for any transport animals or carts which were required. Not only was delay caused by this system when the military train was encamped a long distance away, or when references to other authorities had to be instituted; but, in all instances, it depended upon the exigencies of other parts of the army in the field whether the necessary amount of hospital transport could be afforded. Thus, to use the language of the explanatory letter at the commencement of the revised Code of Regulations of 1859: 'In a case where humanity would suggest that the greatest prudence and forethought should be exercised in alleviating human suffering, the necessities of the sick and wounded are left subject to the ordinary accidents and contingencies of the field.'

The inconveniences experienced in the mode of supply just described led to the changes which were embodied in the revised Code. In these regulations a defined scale of hospital equipment was appointed for every battalion, brigade, and division of an army, while a certain amount of horse and wheel transport was allotted

for its conveyance in the same way as was done for other stores to the artillery and other branches of the military service. In time of war, under all circumstances, the proportions of equipment and transport defined were ordered to accompany the forces to which they had been respectively allotted. In case of events causing an increase of the fixed establishment to be necessary, this addition was to be obtained, so far as the exigencies of the service would permit, by proper requisitions countersigned by superior authority. No countersignature was required for keeping up the stock of regular equipment; to prevent delay, especially when a move was ordered, any deficiency in this stock arising from its diminution by use, was to be replaced on the requisition of the surgeon in immediate charge—a copy only of the requisition being transmitted to the principal medical officer. It was the duty of the senior purveying officer in the command to provide the medical comforts, hospital stores, and field equipment. The transport was to be supplied from the military train.

The hospital equipment ordered by the regulations above-mentioned to be issued to officers of the medical department on taking the field was carried in small portable cases called 'medical field companions'; in larger cases called 'field panniers'; while the bulkier articles of hospital equipment were carried in carts. The equipment was ordered to be distributed in the following way: Each battalion was supplied with one medical field companion, to be carried by an orderly; two field panniers, forming a load for one mule; and one two-mule cart for hospital equipment. There was, also, a two-horse ambulance car, capable of carrying six or eight wounded men, for each battalion. In addition, each brigade of three regiments had a reserve store of hospital equipment and medical comforts; and these were supplemented by a still larger divisional reserve store of the same nature. The quantities of these reserves were laid down in the regulations. The principle maintained was that every division of an army should be prepared for subdivision into brigades or battalions, with their hospital equipments complete, and proportioned to the probable wants of the separate parts; while again, on the subdivisions being reunited, the means should exist for promptly supplying deficiencies which use, or a sudden casualty, might have caused in any part of the force.

The plan of having a fixed hospital equipment for issue to troops on taking the field was an immense improvement upon the uncertain method of each officer separately making a requisition for what he supposed to be needed. It placed, for the first time, the medical department of the army in the same position, in respect to its equipment, as all the other branches of the military service. But modern strategy has led to the necessity for further improvements. It has elsewhere been shown that the system of each

regiment taking with it a hospital of its own into the field is an impracticable one in modern warfare. Independently of the uneconomical nature of a system which leads to an unnecessary multiplication of articles where a limited number would suffice, it has become impossible for troops moving in the field as quickly as they now do to take such cumbrous stores with them. Whenever the plan has been attempted in recent wars it has been found necessary to abandon it.

Articles composing field-hospital equipment.—But though the manner in which the equipment was arranged to be distributed has been condemned, the articles composing it have not been all found equally faulty. Some of them are as good for their purposes as are to be found of the same kind in the hospital establishments of any armies. The several kinds of field-hospitals described in the previous chapter—the field stations, dressing stations, and field-hospitals properly so called—require many of the articles of the service equipment that were in use under the system laid down in the Medical Regulations of 1859. The 'Medical Field Companions' will be wanted for supplying temporary needs on the line of march, and at the first line of surgical help in case of action with an enemy. The field panniers will continue to be the best equipment for affording means of giving medical and surgical attention on the occurrence of various casualties for which the smaller 'Medical Field Companion' is not designed; for use when detached bodies of troops halt for the night on the line of march; on the occasion of slight skirmishes with detachments; in mountain warfare; and under all circumstances when wheeled vehicles are inadmissible. The Bearer Company, under ordinary circumstances, will require wagons for equipment, surgery wagons, and ambulance wagons. Lastly, field-hospital equipment vehicles with the same kinds of contents will still be required for the field-hospitals, though the carts ordered for the purpose by the regulations of 1859 were proved to be faulty, and other kinds of conveyances have had to be substituted for them.

It is necessary, therefore, for army surgeons to be acquainted with the nature of this equipment, the uses of the articles composing it, and the best means of keeping them in serviceable order in the field, and a description of them is accordingly now given.

Field medical panniers.—Of all the articles of equipment which have hitherto been taken by surgeons into the field, the most useful have been found to be the 'Medical Panniers.' They consist of wicker baskets covered with hide, and are each 2 ft. 3 in. in length, by 1 ft. $2\frac{1}{4}$ in. in breadth, and 1 ft. $4\frac{1}{2}$ in. in depth. When about to be carried on a march, the two panniers are first fastened together by certain leathern straps which are permanently attached to them for the purpose. They are then secured to a pack-saddle upon a bât-horse or mule, in such a way that one pannier rests on

each side of the animal. The arrangements made for opening the panniers—the lids being capable of being raised upwards, while the fronts can be lowered downwards—enable all the contents of the two panniers to be readily got at without removing them from the animal that carries them. The handy size of these cases, their lightness combined with their toughness, the impunity with which they can be exposed in all climates and to all kinds of weather, are

Fig. 39.

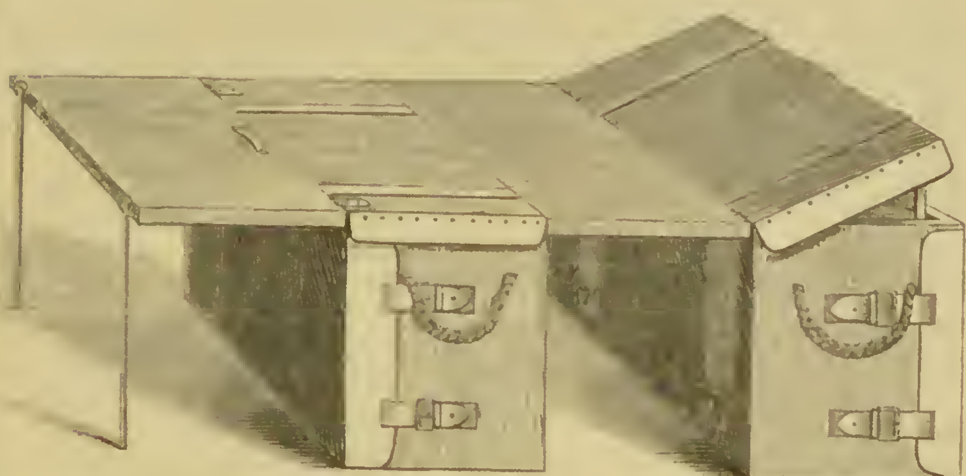
Manner in which Field Medical Panniers are carried.

qualities which make them the most suitable receptacles for portable field stores that perhaps can be devised.[13] Wherever a soldier can go, there the mule with the field panniers can follow, so that they need never be separated from the surgeon or the neighbourhood of the wounded. Their combined weight, when filled, is about 200 lbs., or one mule's load. Similar field panniers were sometimes used during the Peninsular War, but they only opened at the top, and were weak and unwieldy cases; while, at other times, the contents were carried in wooden chests bound with

iron. Both kinds were inferior in all respects to the panniers just described.

Recent improvements in the field panniers.—An improvement, occasionally of great value on field service, was made in the medical panniers after the war in the Crimea. When the two panniers are placed on the ground, they can now be arranged to form a very fair substitute for an operating table. This end is accomplished by each pannier being furnished with a double lid, and with means of so joining the four lids together that a substantial support for a patient, nearly 5 ft. in length, can be formed by them. The plan for forming the table is simple, and will be best understood by reference to the illustration (fig. 40). The advantages, both to surgeons and patients, of always having such means of support on the field, in case of a necessity for the performance of amputations, are very considerable: for circumstances have often occurred

FIG. 40.



Panniers arranged to form a substitute for an Operating Table.

which have prevented the regular operating tables in the wagons from being available near the field of action when they have been wanted, and when no other substitutes have been at hand. Some minor improvements were also made at the same time, especially the introduction of a supply of medical comforts (only surgical materials and medicines having been carried in them previously); the use of patent bottles to prevent accidents from poisonous drugs; and a generally simpler and handier arrangement of all the contents. After the China War of 1860 an improvement was made in the position of the surgical instruments in the panniers. It was found that from being placed at the bottom of the pannier they were liable to become wetted in fording rivers; a fresh arrangement of the contents was, therefore, made by which they were placed on a fitting support at the top. After the Franco-German War of 1870–71 sundry other improvements were introduced.

Among the more important of these has been the introduction of an irrigator for cleansing wounds, of hypodermic syringes and prepared solutions for use with them, metal wound-washing dishes, carbolised tow, triangular bandages, four wicker dressing-trays with the usual dressings ready for use, and a book and tallies for specification of wounds. The alterations have been so made as not to increase either the bulk or weight of the panniers.

Contents of field panniers.—The complete contents of the latest pattern panniers are the following:—

Contents of No. 1 Field Pannier.

MEDICINES.

Acidum carbolic.	oz.	4
Acidum gallic.	,,	1
Acidum sulphuric.	,,	2
Acidum nitric.	,,	2
Ammoniæ carb.	,,	2
Antimonium tart.	,,	½
Argenti nitras	,,	1
Chlorali hydras	,,	2
Chloroform (in three bottles)	,,	14
Cupri sulphas	,,	1
Hydrarg. subchlor.	,,	2
Ipecacuanha contrit.	,,	2
Jalapa contrit.	,,	2
Liquor ferri perchlor. fort.	,,	4
Liquor iodi	,,	1½
Liquor morphiæ ac. (for hypodermic injection)	,,	2
Mixture for diarrhœa, &c.	,,	4
Morphiæ acetas	,,	½
Mustard leaves (Rigollot's)	tin	1
Ol. terebinthinæ	oz.	4
Ol. olivæ	,,	8
Ol. crotonis	,,	½
Ol. menthæ pip.	,,	½
Opium contrit.	,,	2
Pil. colocynth. comp.	,,	4
Pil. hydrarg.	,,	1
Plumbi acetas	,,	1
Potassæ permang.	,,	2
Pulvis ipecac. comp.	,,	1
Pulvis Jalapæ comp.	,,	½
Pulv. cretæ aromat. c. opio	,,	6
Pulv. kino comp.	,,	1
Quiniæ sulphas	,,	4
Sodæ bicarb. pulv.	,,	2
Spir. ammon. aromat.	,,	8
Spir. ætheris nitrosi	,,	2
Spir. chloroformi	,,	1½
Tinct. opii	,,	8
Ung. cetacei	,,	8
Zinci oxidum	,,	1
Brandy	pt.	1½
Water	,,	1½

SUNDRIES.

Lamp (match boxes at bottom)	No.	1
Irrigator	,,	1

PILLS, IN BOTTLES.

Calomel, 1 gr. in each pill	No.	136
Plumbi acet., gr. iii. / Opii pulv., gr. i. } in each pill	,,	48
Calomel, gr. ii. / Pil. coloc. co., gr. iii. } in each pill, 3 bottles	,,	144
Pulv. opii, gr. i. in each pill	,,	144
Quiniæ sulph., gr. i. in each pill	,,	108

MATERIALS.

Corkscrew	No.	1	Drawer No. 1.
Knives (1 palette and 1 pill)	,,	2	
Scissors	pair	1	
Blank labels (linen backs)	No.	100	
Grain scales and weights	set	1	
Pens, ink, and ink powder			
Hypodermic syringes	No.	2	
Writing paper	quire	½	
Envelopes with linen lining	No.	25	
Blotting Book	,,	1	
Camel's-hair pencils	,,	6	
Book and tallies for Specification of injuries and treatment	,,	1	
Gallipots	doz.	½	Drawer No. 2.
Pill boxes	nests	6	
Measures (a 2 oz. and 3 minim)	No.	4	
Indiarubber tubing (2 sizes, large for irrigation and small for draining)	feet	6	
Stopcock for irrigator	No.	1	
Ivory jets for irrigation	,,	3	
Horn cup, graduated	,,	1	
Pestle and mortar	,,	1	
Corks (vial and pint)	doz.	3	
Vials, ½ oz.	No.	6	
Packthread	ball	1	
Cotton wool	lb.	2	Cmpt. No. 3.
Calico bandages	No.	10	
Triangular bandages	,,	12	

Basket No. 4.

Arrowroot	lb.	1
Extract of meat	,,	1
Cocoa and milk	,,	1
Black tea	,,	1
Sugar	,,	2

Wax candles (27) 3 candlesticks, with matches		
Saucepan and two percolators		
Spoons (Nickel) small	No.	2
Tin drinking cups	,,	3

Contents of No. 2 Field Pannier.

Calico bandages	No.	12	Wallet A.
Tenax or oakum	lb.	½	Wallet A.
Splints	set	1	Wallet B.
Tenax, or oakum	lb.	½	Wallet B.
Calico bandages	No.	2	Wallet B.
India-rubber enema	,,	2	Wallet B.
Calico bandages	,,	12	In basket C and also in basket D.
Lint	lb.	¼	In basket C and also in basket D.
Sponges (in two bags)	No.	12	In basket C and also in basket D.
Field tourniquets	,,	4	In basket C and also in basket D.
Screw ditto	,,	2	In basket C and also in basket D.
Emp. Adhesiv. (in two tins)	yds.	2	In basket C and also in basket D.
Emp. Icthyocolli ditto	,,	2	In basket C and also in basket D.
Small stoppered bottles in 2 stands	No.	6	In basket C and also in basket D.
2 leather cases containing:—			In basket C and also in basket D.
Ligature thread	oz.	1	In basket C and also in basket D.
,, silk	,,	1	In basket C and also in basket D.
Surgeon's needles	No	24	In basket C and also in basket D.
Wax	oz	¼	In basket C and also in basket D.
Broad tape	pieces	2	In basket C and also in basket D.
Pins	paper	1	In basket C and also in basket D.
Scissors	pairs	2	In basket C and also in basket D.

Linen sheeting	yds.	3	Wrapper E.
Calico	,,	2	Wrapper E.
India-rubber cloth	,,	2	Wrapper E.
Gutta-percha tissue	,,	2	Wrapper E.
Oiled silk	,,	2	Wrapper E.
Oiled paper	sheets	12	Wrapper E.
German hospital cloth	yd.	¾	Wrapper E.
Angular zinc basins, for washing wounds	No.	2	
Bed pan, with lung	,,	1	
Admission and discharge		1	Books strapped in the lid.
Medical certificate		1	Books strapped in the lid.
Case book		1	Books strapped in the lid.
Hospital book		1	Books strapped in the lid.
Returns of wounds		6	Books strapped in the lid.

The illustrations (figs. 41, 42) show the manner in which the contents are arranged in the two panniers.

Book and tallies for specification of injury and treatment.—The necessity for briefly recording any special circumstances connected with a wound or its treatment, after it has been seen and attended to by a surgeon, in order to prevent unnecessary future interference, has been previously referred to. The book and tallies in No. 1 pannier have been introduced for this purpose. The book serves merely to keep the tallies together. The tally consists of a piece of strong linen material, prepared for being written on, 4½ in. long by 2½ in. broad. It is double at one end, where it is punched and slit ready for being affixed to a button of an uniform coat. The following headings are printed upon it:—

No. and Name ____________________

Rank and Regt. ____________________

Wound ____________________

Treatment ____________________

Signature of Surgeon ____________________

[1] NOTE.—These baskets are constructed and their contents arranged to form four dressing trays when occasion requires, for which purpose there are four sets of the articles contained in the two baskets, so that half of the articles above specified are for each dressing tray.

Tallies are now being introduced with a counterfoil, arranged like a banker's cheque-book, so that a copy of the remarks on the tallies may be retained by the surgeons who make them.

Care of field panniers.—It is so extremely important for the welfare of patients as well as for the surgeon's efficiency, when the contents of the field panniers constitute the chief surgical and medical resources of the surgeon in charge of a body of troops, that the panniers should always be at hand, and in good order for use—on the line of march, after an action, and, indeed, in all the varied operations of field service—that a few hints are added for the purpose of helping to ensure these objects being accomplished.

FIG. 11.

No. 1 Field Pannier open to show the arrangement of the contents.

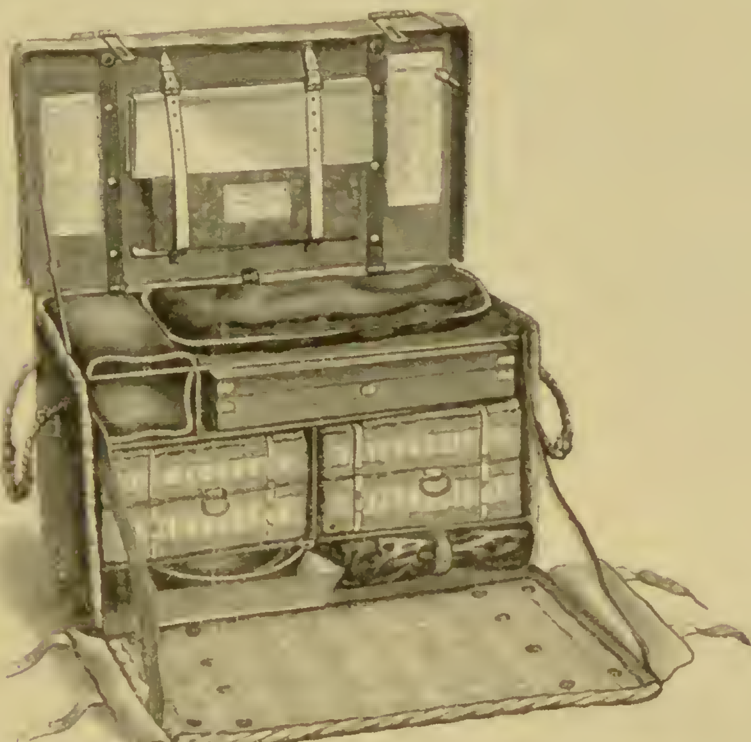
Pannier-mule.—The mule or pony to be employed in carrying the panniers should be selected not only for its strength, but also for good temper. Care should also be taken that the orderly told off for the duty of leading it is a man who is likely to be kind and attentive, and who understands something of this particular charge. Nothing can be more harassing for a surgeon on a line of march than to find the pannier-mule proving restive, or perhaps breaking away from the orderly with the panniers. An untrained or vicious pannier-mule is a constant source of trouble and anxiety.

Pack-saddle.—It should be carefully ascertained, before starting

on a march, that the pack-saddle is complete and strong in every respect, and particularly that it sits easily upon the back of the mule. It is very difficult to get any repairs done when once a march has commenced, and, if the saddle galls the mule anywhere, however quiet the animal may be naturally, it will certainly become troublesome so long as the load is upon it.

Weight of panniers to be evenly balanced.—The two panniers should always be so weighted as to balance each other as accurately as possible. The burden to the mule will be rendered much easier by attention to this rule, and the object can always be accomplished with a little management. There is scarcely any differ-

FIG. 42.



No. 2 Field Pannier open to show the arrangement of the contents.

ence in the weights of the two panniers—not one pound—when their contents are completed according to regulation.

On no account should articles beyond those defined by regulation be permitted to be placed upon the pannier-mule, or the animal will be overloaded. Attempts will not unfrequently be made on a march to get the medical officer's consent for a cloak, or some such parcel, trifling in itself, to be carried on the top of the panniers. The only way to escape these importunities is to have a decided rule at starting that nothing, under any circumstances, is to be added to the regulated articles which the mule is appointed

to carry. As before mentioned, the panniers and their contents weigh about 200 lbs., and this is a full weight for the animal, having regard to its always keeping up with a column, and being at hand when wanted. The only occasion when any addition to this weight should be permitted, is when military circumstances render it necessary to carry some rations of corn or forage for the animal's use.

Distribution of contents of panniers.—The regulated arrangement of the articles contained in the panniers should on no account be changed, even in the smallest details. The contents cannot be better distributed than they are in the authorised method, which is clearly indicated by special divisions within the panniers, and in the printed directions upon them. The fixed distribution prevents waste of time when articles are required at short notice. Moreover, it is easier to ascertain if any deficiencies exist, when the allotment of the several materials and medical comforts in their regulated compartments is not permitted to be disturbed.

Deficiencies in panniers.—The earliest opportunity should always be taken of replacing deficiencies in the panniers from reserve stores. The panniers are to surgeons what ammunition is to combatants; and, on active service, the necessity for any part of their contents may arise at a moment's notice.

Surgical instruments.—The preservation of the surgeon's instruments which are carried in the panniers should have particular attention. This is essentially important under circumstances where, if knives become much injured, it may be impossible to get them repaired. It is a good plan in the field, after surgical instruments have been used and cleaned properly, to apply some oil or ointment to their surfaces, and afterwards to remove by means of a dry cloth all the grease which is readily visible; the fine coating which will still remain acts as a protection against the damp vapours which rise from the ground in tents, and are exceedingly penetrating. In well-protected buildings such applications to instruments are not only unnecessary, but are generally considered to be injurious. In campaigning, however well covered an instrument case may be, even though the covering may be waterproof, instruments are found to become rapidly rusty, and it is absolutely necessary to examine them at frequent intervals. A useful addition for a surgeon to make to the contents of the panniers will be a hone and strap for sharpening the edges of his knives when they become blunted. It will not answer to depend upon a cutler, though one may be attached to the army; he may be a long distance off at the time his services are required.

Means of light.—Means of light are now provided by a plentiful supply of wax candles in the No. 2 pannier. The want of light has been a source of great loss of time to surgeons in the field, and suffering to patients, in former campaigns, especially

when surgical operations have been necessary at night time. Many operations, that would otherwise have been done, were stopped after nightfall, on the occasion of the battle of the Alma, owing to want of means of light. This neglect caused delay at a time when an advance was most important for military reasons, and needlessly prolonged the misery of the wounded. The provision of light now made in the panniers is so ample, that, with proper care, no suffering from want of this requisite should be permitted to occur in future, even when surgeons happen to be depending on this source of supply alone. The candles are placed in separate tin compartments, so that they may not become injured by contact. They are used in a convenient kind of lamp, furnished with a movable reflector, and made so as to be held in the hand or suspended by hooks, as occasion may require. The light can be concealed when necessary, without putting it out—often an important point in the field. The lamp is also arranged for heating a small metal vessel of water, with which to prepare some warm drink, such as a cup of beef-tea, or of cocoa and milk, which are among the medical comforts contained in the No. 1 pannier.

Case of instruments carried in the surgeon's shoulder-belt.—All army medical officers under the rank of Deputy Surgeon General, when on active service in the field, carry a regulation case of pocket instruments in the authorised undress shoulder-pouch, which is worn as part of their uniform. The surgeon's shoulder-belt answers a twofold purpose. As an article of dress, it indicates the wearer to be an army medical officer, and also, by certain differences of ornament, serves in the field to distinguish between the executive and administrative officers of the medical department. Combatant officers of infantry wear silk sashes over the shoulder; officers of the General Staff, Cavalry, Engineers, Army Hospital Corps, Commissariat, and other departments, wear shoulder-belts of peculiar colours or patterns, fitted for field-glasses or for writing materials, all distinct from one another and from those of medical officers. The latter may, therefore, be readily distinguished by this article of uniform. This is especially important on field service, when a surgeon should be capable of being recognised on the instant. Secondly, the shoulder-belt serves to carry the pouch, which is made to contain the small case of surgical instruments before referred to. This arrangement insures the constant presence with the surgeon of these appliances which are so essential to his professional usefulness. All executive officers, who have a due regard to their own efficiency, will take care to keep their instruments in a state ready for use; but it is one of the duties of surgeons of general rank, to make sure that they are maintained thus complete and in good order.

The following is a specification of the 'Surgeon's pocket case' and its contents, of the latest pattern.

No.	Instruments and other Articles	Dimensions (Inches)
1	Probe curved, and straight sharp-pointed, bistouries, in one handle	$3\frac{7}{8}$
1	Syme's abscess knife, and double-edge scalpel, in 1 handle	$3\frac{7}{8}$
1	Tenaculum and gum knife, in one handle . .	$3\frac{7}{8}$
1	Pair crooked scissors	$4\frac{3}{4}$
1	Spatula, German silver	$4\frac{1}{4}$
1	Bow dressing forceps	$4\frac{3}{4}$
1	Director and aneurism needle, plated . . .	$4\frac{3}{4}$
1	Pair artery forceps, fenestrated	$3\frac{1}{4}$
2	Probes, plated	$4\frac{3}{4}$
1	Male and female silver catheter combined . .	$4\frac{3}{4}$
1	Caustic-case with palladium crayon	$4\frac{1}{4}$
1	Clinical thermometer	4
1	Case for ditto, plated	$4\frac{1}{8}$
2	Lancets	$2\frac{1}{4}$
2	Dieffenbach's forceps	2
1	Silver hypodermic syringe, in case	3
6	Needles, plated	$2\frac{1}{2} \times 2\frac{1}{8}$
1	Tablet of silk and wire for sutures . . .	
	All contained in a Morocco single-flapped case of the following dimensions	Length $5\frac{1}{4}$; Breadth $2\frac{5}{8}$; Thickness at clasp $1\frac{1}{4}$
	Total weight with instruments $9\frac{1}{4}$ ozs. . . .	

The surgeon's pocket case differs from the army regulation pocket case, of 'full set' pattern, in containing a less number of instruments. The 'full set' pattern is for hospital use, and forms part of the equipment of the field-hospitals. The 'surgeon's capital case of instruments' of the new army regulation pattern varies in a similar respect from the capital case of instruments which is supplied as part of the surgical equipment of field-hospitals.

Surgeon's capital case of instruments.—This is carried in the No. 2 Field Pannier. The contents of this case are the following:

	No.		No.
Bistoury, straight sharp-pointed .	1	Liston's needle, in handle . . .	1
" curved " .	1	Steel aneurism needle . . .	1
" " button-pointed .	1	Half-curved needles for sutures . .	6
" for hernia	1	Gunshot probe, silver . . .	1
Double tracheotomy cannula, silver .	1	Amputating saw, single . . .	1
Elastic gum catheters, Nos. 1, 4, 7, 9	4	Saw, with movable back . . .	1
Silver catheters, Nos. 3, 5, 8 . .	3	Scalpels	3
Steel hernia director	1	Tang scalpel	1
Double elevator	1	Common tenaculum	1
Liston's artery forceps, pair . .	1	Screw tourniquet	1
Bone forceps, pair	1	Trephine, medium	1
Bullet forceps, pair	1	Hydrocele trochar	1
Dieffenbach's forceps, pair . .	1	Ferguson's thread, oz . . .	$\frac{1}{2}$
Dissecting forceps, large, pair . .	1	Extracting probang, double . .	1
Bladder trochar and cannula . .	1	Reel of ligature silk	1
Liston's knives, 6, 9 and 11 in. . .	3	Reel of wire for sutures . . .	1

Medical field companion.—Infantry soldiers on active service carry a haversack made of strong canvas, with the upper part

buttoning over. It is slung by a band across one shoulder, and forms a convenient receptacle for various articles not included in the field kits. It was the custom in former years, in campaigning, for hospital sergeants to employ these haversacks for carrying lint, bandages, and other materials for dressings, together with a small supply of medicines ready prepared for use, in order to avoid frequent recourse to the field panniers. Some practical inconveniences

FIG. 43.

Medical Field Companion.

were experienced in employing them for this purpose, owing to the yielding qualities of the canvas: especially the readiness with which glass articles carried in them became broken, together with difficulties in the way of keeping their contents dry in wet weather, as well as separate and in good order under ordinary circumstances. After the Crimean War, a regular substitute for the haversack was devised in the form of a substantial leathern case, arranged to be carried in a similar way by a strap passing over the shoulder. One

of these cases was, for the first time, furnished to each regiment and corps engaged in the Expedition against Canton in 1857, and was found to be exceedingly convenient for the purpose designed. It was divided into suitable compartments, each properly fitted; the contents were thoroughly protected from the effects of damp; the medicines selected were chiefly prepared in powders or pills, ready for administration; the appliances consisted of articles necessary for the first dressings of simple injuries; and there was a supply of cholera mixture, tincture of opium, and a few other essential remedies for urgent cases of sudden illness. A tin water bottle, and graduated horn cup also accompanied the case. This useful appliance was called the 'Medical Field Companion.' Its weight was 11¼ lbs. This is still the authorised pattern by the Army Medical Regulations, and is the one retained in the Army Medical Stores. It cannot be carried by infantry soldiers in marching order. In cavalry regiments it has been usually carried, slung across the shoulder of the farrier, or some other sergeant, on the march, but it is by no means suitable in shape for carriage by mounted men. A suitable pattern has yet to be devised for this arm of the service. With field artillery, it is generally attached to the footboard of a gun limber.

The following are the contents of the Medical Field Companion authorised by the Army Medical Regulations of 1859:—

Contents of the Medical Field Companion.

MEDICINES.

[1] Mixture for diarrhœa and cholera	oz. 2
Chloroform	„ 2
Tinct. opii	„ 2
Spirit. ammoniæ aromat. . .	„ 2

PILLS.

Tins.		
No. 7	Calomel gr. i. pulv. opii gr. i. in each.	4 dozen of each kind.
„ 8	Plumbi acet. gr. iii. pulv. opii gr. i. in each.	
„ 9	Calomel gr. ii. pil. rhei co. et pil. coloc. co. gr. i. in each.	
„ 10	Camphor gr. iii. pulv. opii gr. ii. et pulv. cayenne gr. ½ in each.	

POWDERS.

No. 1	Morph. acet. gr. ½ plumbi acet. gr. iv. et pulv. acac. gr. ii. in each.	24
„ 2	Antim. tart. gr. i. pulv. acaciæ gr. iii. in each.	12 of each kind.
„ 3	Calomel gr. iii. pulv. jacobi gr. v. et pulv. ipecac. co. gr. xv. in each.	
No. 4	Pulv. kino co. ℈ i. in each .	24
„ 5	Pulv. cretæ co. c. opio ℈ ii. in each. .	12
„ 6	Pulv. Jalapæ co. ℈ ii. in each .	12

APPLIANCES.

Calico rollers	2
Suspensory bandages . . .	2
Clavicle bandages . . .	2
Strong calico	yd. ½
Linen sheeting	„ ½
Lint	lb. ¼
Gutta-percha tissue . . .	yd. ¼
Cotton wool	lb. ¼
Isinglass plaster	yd. 1
Adhesive plaster	„ ½
Sponges, surgeon's . . .	2
Needles	25
Whited brown thread . . .	oz. ½

Razor in case.
Shaving soap, 1 roll.
Screw field tourniquet.
Candle and wax matches.
Pins ½ paper, tape 1 piece, scissors 1 pair.
Minim measure, 1.
Graduated horn cup, 1.

[1] Note.—Ol. anisi, ol. cajeput, ol. juniperi ā ā ʒ iss., liq. acid halleri, tinct. cinnam. ā ā ʒ ij. m. Marked 'to promote reaction in diarrhœa and cholera—10 drops every quarter or half hour in a tablespoonful of water.'

Although no inconvenience was experienced by infantry soldiers in carrying the Medical Field Companion in China, where they have their knapsacks carried for them, this cannot be done in Europe where no such practice is followed. It is generally regarded in the British army as a military necessity that soldiers shall never be divided from their field necessaries, and this has been especially enforced since the experience of the evils which resulted from the men being separated from them in the early part of the Crimean War. The question of the best mode of carrying the Medical Field Companion attracted the attention of the committee at whose recommendation the knapsack was replaced by the present valise equipment of the infantry, and experiments were subsequently instituted on the subject. As, on the one hand, it was laid down as essential that the valise equipment should be worn for the carriage of the soldier's field necessaries, and as, on the other, the hospital sergeants or orderlies, by whom the Medical Field Companions would have to be carried, were not required to carry ammunition (not being armed with rifles), one ready way which suggested itself for the carriage of the contents of the Medical Field Companion was by utilising the ammunition pouches to hold the medicines, and by substituting for the ball bag a larger bag to carry the surgical materials. The necessary balance of the valise equipment on the waist-belt would thus be maintained, the supplies be always ready at hand for distribution, while the weight to be carried would be no greater than that carried by every infantry soldier. Two medical pouches and a surgical bag were adapted to the valise equipment on the principles just named, and some sets of these were tried at the autumn manœuvres of 1872, and were favourably reported upon, so far as regarded their employment by infantry soldiers. The drawing (fig. 44.) shows the manner in which they were carried. They have not, however, been officially sanctioned.

Fig. 44.

Medical Field Companion adapted for carriage by hospital attendants wearing the valise equipment.

The contents of the valise Medical Field Companion, thus arapged, were distributed as follows:—

Distribution of the Contents of the Medical Field Companion as adapted to be carried by Sergeants or Orderlies wearing the Valise Equipment.

CONTENTS OF SURGICAL BAG.

In small compt.	1 Pocket case containing—
	1 Paper of pins
	2 Pieces of tape
	1 Skein of white thread
	12 Ligature needles.
In large compartment.	2 Calico bandages
	2 Field tourniquets
	1 Screw ditto
	2 Suspensory bandages
	2 Minim measures
	2 Cases for ditto
	1 Graduated measure (horn)
	3 Triangular bandages
	1 Candle and tin case
	2 Sponges
	1 Sponge bag
	½ yd. oiled silk
	¼ lb. lint
	1 Tin case containing—
	¼ yd. Isinglass plaster
	¼ „ adhesive ditto

CONTENTS OF MEDICAL POUCHES.

Medical Pouch No. 1.

Chloroform	oz.	2
Spiritus ammon. aromat.	„	2
Tinct. opii	„	2
Diarrhœa and cholera mixture	„	2

Medical Pouch No. 2.

In tin case No. 1.	12 Powders pulv. jalap. co.	each gr.	10
	12 Powders pulv. kino co.	„ „	20
	12 Powders pulv. ipecac. co.	„ „	10
	12 Powders antim. tart.	„ „	1
	12 „ ipecac. contrit.	„ „	20
In tin case No. 2.	12 „ quinine	„ „	2
	4 Dozen pills quinine	„ „	2
In tin case No. 3.	4 Dozen pills calomel	„ „	1
	1 Doz. pills plumbi acet.	„	3
	opii pulv.	„	1
	4 Doz. pills calomel	„	1
	pil. coloc. co.	„	2
	4 „ „ pulv. opii	„	3

The medicine pouches and bag of surgical materials can be equally well carried when the waistbelt alone is worn, or when the soldier is either partly or completely equipped with the valise equipment, and under each condition their contents can be got at without difficulty. When the valise and greatcoat are worn, the surgical bag is carried in front, in the same way as the large ammunition pouch is carried by soldiers of the Belgian army, and as the 'tourist bag' has been worn by pedestrians with the valise equipment in accordance with the designs of Professor Parkes. When the valise is not worn, the bag can be shifted round the waistbelt, and carried behind in its place. The shifting can easily be effected without unfastening the waistbelt, if the pouches and bag be passed over the end of the waistbelt to which the tongue is attached, and not from the opposite direction. The weight of the two medicine pouches and surgical bag, complete with their contents, is 6 lbs., or nearly half that of the former pattern; and, as the reduced weight is more widely distributed, it is also on this account more easily borne than that of the original medical field companion. The diminution in the weight has been obtained without lessening the efficiency of the contents. A few alterations in them have been made. For chloroform, which, as a general rule, is only used in the field in combination with surgical instruments—and they are carried

elsewhere—the liquor of the perchloride of iron, a powerful styptic which may often be applied with advantage at the first lines of surgical help, has been substituted. The supply of quinine and opium has been increased. The other changes are of minor importance, and can be readily seen by comparing the contents of the two forms of medical field companion.

It has been suggested, in respect to cavalry, that it would be more convenient to arrange the contents of the medical field companion in saddle-bags, or in a cavalry valise, than in the form of case at present authorised, carried across the shoulder. Some conveniently arranged saddle-bags for this purpose are in use in the Belgian cavalry (Sacoches pour la cavalerie). On the other hand, it is considered by some officers that the medical field companion ought always to be arranged for being readily carried on the person of a soldier; for otherwise, in case of the horse to which it is attached being shot or getting loose, and, without this accident occurring, under many circumstances in which wounded men are liable to be placed, the assistance which the appliance is designed to render could not be afforded. The surgical bag of the infantry valise medical field companion cannot be carried by a mounted soldier either in front or behind, owing to the accoutrements on the saddle. It has therefore been suggested that while the two medicine pouches are carried on the waistbelt, the contents of the surgical bag might be carried in a light case slung across the shoulder and of the same shape as a mounted orderly's letter-bag.

Surgical knapsacks. A certain number of knapsacks specially fitted with surgical dressings and appliances, are carried in all Continental armies with each battalion of infantry. They take the place of the English Medical Field Companions. In some armies the surgical knapsacks are carried on the march by the surgeon's orderlies, special provision being made for the carriage of their own field kits and knapsacks; in others the surgical knapsacks are carried in the pharmacy wagons, and are only put on by the orderlies when occasions arise for their employment. Obviously men cannot carry their own knapsacks and the surgical knapsacks at the same time. Medical field companions are also more convenient than surgical knapsacks, because their contents can be distributed by the wearers without removing them from their persons, which cannot be done with the knapsacks; while, if removed for any purpose, they can be more easily and rapidly put on again than knapsacks.

The 'first field dressing.'—The stores already described should be wherever surgeons and their hospital attendants are employed; but, during the Crimean War, a plan was adopted for making sure that by no accident should any soldier be wounded and means for dressing and bandaging his wound not be at hand, in whatever part of the field he might fall. By an Army Medical Department cir-

cular, dated May the 27th, 1855, medical officers were informed that the Secretary of State for War had decided that a 'field dressing' should form a component part of every British soldier's kit on active service, so as to be available at all times, and in all places, as a first dressing for wounds. The materials and form of the 'first field dressing' were ordered to be as follows:—Bandage of fine calico, 4 yards long, 3 inches wide; fine lint, 12 inches long, 3 inches wide, folded flat and fastened by 4 pins. It was carried in the soldier's knapsack. This plan for ensuring the presence of means for dressing wounds in the field has since been adopted in nearly all armies. On the occasion of the Ashanti War of 1873–74, the materials composing the 'first field dressing' were altered in several particulars. The dressing included a packet of lint, on which a little simple ointment had been spread, enclosed in waxed paper; a triangular bandage; two safety pins, and a small packet of ordinary pins. The whole of these articles were folded into a small flat package $4'' \times 3\frac{1}{2}'' \times 1''$, in dimensions, which was covered by waxed paper. It was carried in a breast-pocket of suitable size on the left side of the tunic.

This was a better place for keeping the 'first field dressing' than the knapsack or valise. On many occasions, in fighting, combatants will disencumber themselves of their valise equipment, and some hours may elapse before they are again obtained. If placed in the valise, therefore, the field dressing may be absent at the very moment it is wanted, and on the particular occasion for which it was contrived. On this account, in foreign armies, other arrangements are usually made for its carriage. By the Prussian regulations of 1869 every North German soldier was provided with materials for a first field dressing consisting of some charpie, a compress of linen, and a bandage. In the infantry it was ordered to be carried in the left trouser pocket; among hussars and lancers, it was sewn in the front lappet of the uniform jacket; in other regiments of cavalry, in the coat-pocket behind. It would be well if arrangements for carrying it in a breast-pocket of the tunic were made, as was done in the Ashanti expedition, in case of English troops being engaged in future war. Dr. Esmarch has recently proposed new contents for the 'soldiers' first dressing.' He exhibited patterns of them at the Brussels Exhibition in 1876. Each 'first dressing' was composed of one triangular handkerchief with a safety pin; four small packets of 10 per cent. salicylised cotton charpie enclosed in varnished paper; one piece of salicylised gauze bandage, about $4\frac{1}{2}$ inches broad by 1 yard long; and four common pins. The whole were made up into a small packet, and wrapped in waxed paper.

Case of instruments and dressing-pouch for hospital attendants. The medical field companion has only been designed for being carried by a hospital-sergeant, or special orderly in attendance on

a surgeon. The medicines contained in it are such as should only be administered under the directions of a qualified practitioner. But all hospital attendants of the Army Hospital Corps require some convenient means for executing the minor operations connected with surgical patients, which they are taught to practise. In removing foul dressings, and performing various acts of attention to wounds and sores, these men have hitherto habitually used their fingers. Occasionally this procedure leads to mischief to the wounded patients, and also to their attendants. Sores are sometimes produced on the hands of the orderlies which are very difficult to heal.

FIG. 45.

Battle-field Dressing Pouch for trained Bearers of Wounded

A hospital attendant should not have such a pocket case of instruments as a surgeon requires, but one containing only the things which are necessary to enable him to perform the minor surgical work which he is qualified to execute. To cut up a boot for removal from a wounded foot, to adapt and fasten a splint, to cut off a bandage on a director, to sew up linen coverings and bandages, to spread ointments on lint, and such minor operations, are things which he has been taught to do, and which it is his legitimate duty to do as occasion requires. In the field, too, the application of temporary dressings to wounds — sometimes in the absence of a surgeon, and occasionally, when many wounded require aid, in the presence, and under the direction, of a surgeon—is work which he has been prepared for, and which it is often very important he should perform.

For the purpose of enabling the hospital attendants to execute these duties properly, Surgeon Moffitt, for some time the Instructor of the Army Hospital Corps, designed a hospital attendants' pocket case and field dressing-pouch. The latter was only designed for time of war, and more particularly for use by trained bearers of wounded. The pocket case was intended to be used by all orderlies of the Army Hospital Corps, in the wards of fixed hospitals as well

as in the field. The instruments in the pocket case, and the materials in the dressing-pouch, have been extremely well selected. They are mentioned below. The pocket-case might be carried in the man's tunic on fixed hospital duty, and to ensure its being always in good order, should form part of the man's necessaries and be shown at all kit inspections. In the field it might be carried in the dressing-pouch. The latter would be worn on the waistbelt, but suspended from the valise equipment straps, as shown in the sketch.

Contents of a Bearer's Field Dressing Pouch.

Screw tourniquet	1	Tape, piece	1
Triangular bandages	4	Tin case, containing ⅛ yard of oiled silk and 36 × 5 of adhesive plaster	1
Roller bandage, 8 yards	1	Pocket case of instruments for hospital attendants	1
Lint, oz.	2		
Tow, or oakum, oz.	2		

Contents of Pocket Case of Instruments for Hospital Attendants.

Scissors, 6 in. long, pair	1	Pins, dozen	1
Spatula, German silver	1	Sewing needles, straight	3
Probe and director, German silver	1	" " curved	3
Dressing forceps	1	Sewing thread, skein	1
Clasp knife	1		

Surgery wagons of the bearer company.—These wagons have the same general characters as the pharmacy wagons with the field-hospitals, presently described; but are lighter and less bulky, and are almost exclusively devoted to the carriage of surgical materials. The medicines, surgical instruments, materials, and appliances are contained in six wicker baskets, properly fitted and covered with hide. They are distinguished by letters: A basket being the only one which contains any medicines, while B to F are filled with surgical instruments and materials exclusively. Each wagon carries, in addition to the baskets, an operating tent; an operating table; two canteens containing cooking utensils and various articles of a serviceable kind for the field; and two medical comfort boxes, each containing about 100 lbs. of medical comforts. There is a third box containing hand lanterns and other articles. Each bearer company is to have two surgery wagons, so that, if one section of the company be detached, each section may be provided with this essential portion of equipment. The surgery wagons take the place, on a larger scale, of the field panniers, whenever the ground admits of the use of wheeled vehicles. They would not be supplied to a bearer company when it is fitted out with mountain equipment; the field panniers on pack animals being alone suitable for the purpose.

Other wagons of the bearer company.—The other equipment wagons and carts of bearer companies are vehicles of army service patterns, without any special hospital features, and need not be

described here. To each company there are two wagons for the tents of the company, two for the field equipment, a supply cart, and two water carts, and thirty-three ambulance wagons. Only the ambulance wagons of the first line, ten in number, are of the service pattern. These will be described with the rest of the sick-transport conveyances.

The field surgical equipment which has been described, provides for all the wants of wounded soldiers on the occasion of a general action, from the place where they receive their wounds, till they reach a field-hospital, where the arrangements comprise the means of complete surgical care and treatment. Each soldier carries on his own person a dressing for a single wound. The medical field companion supplies the means of further dressing, and also contains certain appliances and remedies which may be needed at the first line of surgical assistance, or at the station where the wounded soldier is transferred to a wheeled conveyance. Each surgeon carries a pocket case of surgical instruments for minor operations. The surgery wagon, or, in its absence, the field panniers contain the means of performing all major surgical operations, by night as well as by day, that cannot be deferred with safety until the wounded men reach a field-hospital, and also of supplying various restoratives, both nutritious and medicinal. All the wants that may be expected to occur between the actual place of conflict and the field-hospitals are thus provided for by these parts of the field-hospital equipment.

Field-hospital stores and transport.—It does not admit of dispute that the surgical and other hospital equipment provided for the sick and wounded, are, as they are often regarded, an incumbrance to the fighting parts of an army, both from their bulk and weight, as well as from the requirements of the transport animals and their drivers. But it should be remembered that the sick and wounded are doubly so: on the one hand, they weaken an army by lessening its numbers in their own persons, on the other, by abstracting healthy men to attend upon them. The unfavourable moral influence which the presence of a body of disabled men always exerts, especially when their necessities are more or less disregarded, should also not be forgotten. Therefore the disadvantages in transporting the means which are necessary for preventing, or diminishing, the accumulation of sick and wounded in number, must be balanced against the advantages arising from their employment. But beyond this, the troops have a right to the best precautions which can be taken for their protection, as well as for the safety of their lives, should they become endangered by wounds or sickness received in the service of their country. This is a right which has always been conceded by the greatest commanders, as well of ancient as of modern times. As Sir James McGrigor has remarked, 'It is not only in the sense of humanity

but in that of a sound policy and real economy, that the State should provide able medical and surgical advice for the soldier when sick or wounded. I look upon it to be an implied part of the compact of citizens with the State, that whoever enters the service of his country as a soldier, to fight its battles, should be provided with the same quality of medical aid, when sick or wounded, which he enjoyed when a citizen. In every large town, whence the great bulk of recruits is drawn, there are public hospitals and dispensaries, which, supported by the subscriptions of the rich, are always open to the sick and poor, and to persons of the middle classes; in fact, to those ranks in life from which the soldier comes. The physicians and surgeons of these public institutions are always the ablest men in the profession of medicine.'[14] The same arguments, which are put forth for employing surgeons of knowledge and ability, necessarily apply to providing the means which are required to enable them to apply their talents to the benefit of their patients. At the same time it should always be borne in mind, that the supplies for the hospitals accompanying the troops ought never to be increased one fraction beyond what is absolutely necessary for efficiency. It is always an object to reduce the transport, as far as practicable, when an army is moving near an enemy. From this consideration, that arrangement will answer best which comprehends just sufficient equipment to meet the early wants of the wounded which the field-hospitals are calculated to provide for, and, at the same time, that combines with it a reliable system by means of which fresh equipment can be brought from the rear, as occasion requires, to replace deficiencies in the front. This can be best accomplished by a judicious provision of reserve stores at the base hospitals.

The equipment provided should be calculated for the probable number of wounded that may be expected to require assistance in case of a general action. This calculation can only be based on the results of previous experience. Having established this number, the nature of the casualties which may be expected to occur, and the relative proportions of the different kinds of casualties, have next to be considered. The statistics of former wars, so far as observations on these points have been recorded, must also be relied upon for furnishing this information. Regard should next be had to the probable number of days the wounded may be expected to remain in the field-hospitals; and, when this point has been settled, and the kinds and numbers of the articles of equipment have been agreed upon, all perishable and removable articles may be doubled or trebled in amount, in order that one or two repetitions of similar engagements with the enemy may be provided for. These are the only reasonable principles on which hospital equipment can be estimated for, with due regard to economy and a fair assurance that the demands which will be made on the hospital establish-

ments can be met. Reliable surgical histories of wars, and the statistics derived from them, are thus most important subjects for study by administrative medical officers. Some statistics that may be turned to account in framing the proportions of equipment necessary for the field-hospitals, will be found further on: in the section on ratios of casualties in war.

The hospital stores which have been mentioned in the previous part of the chapter—those for the field and dressing stations—form that portion of the surgical equipment which army surgeons may expect to have always at hand to assist them in the performance of their duties in the field. They have been particularly arranged so that the sick and wounded may be attended to in places and under circumstances where the heavy transport vehicles, containing the bulkier stores of the field-hospitals, cannot be expected to be available. The field-hospital transport, however, can move with the army in all places where the other store-transport can go. The stores which they convey are of great importance to the wounded, and it is essential that they should never be beyond easy reach in case of an engagement happening with the enemy.

As it has been laid down that a movable establishment for 200 sick and wounded men is to constitute the field-hospital unit in future, it is necessary to indicate in a general way what the stores for one of these hospitals will be, and in what way they are to be carried. Circumstances may render it necessary for the troops to move without cover of any sort, as the Germans generally did during the late Franco-German War; while on some occasions cover may be provided. Again, at other times, not only cover but even bedsteads, which all surgeons know to be very necessary for the efficient treatment of many cases of sickness and severe wounds, as well as other heavy articles of ward furniture, may, perhaps, be capable of being carried for use. It seems better, therefore, not to lay down a single scale of equipment for field-hospitals, but to prepare two or more scales of supply to meet the various conditions of campaigning under which the troops may be placed. Thus a scale may be drawn out for the field-hospital equipment when tents are not to be carried: a second, when tents are carried: a third, when not only tents, but field bedsteads, are supplied. On an expedition being undertaken, it would devolve on the officer in command to say on which scale the field-hospitals are to be furnished. In the composition of a field-hospital, shown at page 440, the transport named includes the amount which would be required if tents are carried.

The store-transport equipment of a field-hospital for 200 patients comprises (1) four wagons for the carriage of bedding, utensils, and steward's stores; (2) two pharmacy wagons for the carriage of surgical instruments, dressing materials, and medicines; (3) four wagons for the conveyance of hospital marquees or tents

for patients, when these are supplied, tents for the hospital personnel, operating tents, with the officers' and men's baggage, cooking and other field equipment; (4) additional wagons for the conveyance of bedsteads, supposing—what can rarely happen excepting in standing camps—that these articles are taken into the field; and (5) two water-carts.

The vehicles for the conveyance of the field-hospital equipment consist of general service wagons, but it would facilitate the working of a field-hospital if the wagons for these stores, like the pharmacy wagons, were specially constructed for their particular purpose. The hospital equipment wagon should be divided into suitable compartments so that each description of store may be separately disposed, and any portion of the contents got at, as occasion may require, without disturbing the remainder. There are more than 100 different articles carried in this store-wagon. Good order, a reduction of space and better arrangements in the appropriation of it, a saving of weight and less strain on the draft animals, economy of time in unpacking and packing the stores, prevention of injury and waste among them, and, therefore, in the end, efficiency, would be promoted by a suitable construction and sectional arrangement of the wagons, instead of distributing the stores in separate boxes and placing them on ordinary transport conveyances. The hospital equipment wagon also, like the pharmacy wagon, requires a roof of a sufficiently substantial character to assist in keeping the contents in their respective places, and at the same time to protect them from inclement weather. The objection to such special conveyances from a military point of view is that they cannot be turned to account for other purposes in the public service, and that more wagons are required to be constructed in consequence, but this is an objection which applies equally to all special conveyances. It is an objection which should always be weighed against the needs for efficiency, and, if these preponderate, should be set aside.

The field-hospital equipment wagons, or 'bedding and utensil wagons' as they have been sometimes called, are required to carry all the ward stores and utensils of first necessity for use in the field-hospitals, whether they are established under canvas, in detached buildings, or in a village. These stores include medical comforts, such as essence of beef, arrowroot, tea, sugar, rice, wine, brandy; the different sorts of cooking and table utensils; the bedding; and the essential ward utensils. The stores are intended to provide for all the wants of the wounded who may be admitted into the hospital, in respect to ward appliances, warmth, cooking and dieting; and also to furnish the stewards and attendants with the means of carrying on their administrative duties. Hours may elapse before the commissariat rations, which in the field are issued alike to the patients in hospital and to the healthy, can be supplied and prepared

for their use. In the meantime, if the field-hospital equipment wagons are where they ought to be, the wounded will have all necessary requirements in this and other respects fairly provided for.

The equipment for the 200 patients of the field-hospital is equally distributed among the four wagons. Each wagon, therefore, has a complete assortment of equipment for 50 patients. The following is the list of stores, and their quantities, appropriated to each wagon. The necessity for a well-assorted disposal of them will be apparent on observing the nature of the articles which the list contains. To carry them in general-service wagons, they must be distributed in separate boxes; and this arrangement necessarily increases the dead-weight to be transported, lessens the available space within the wagon, and prevents access to particular stores unless the whole of the boxes are previously removed.

Names and Quantities of Articles contained in the Field-Hospital Store, or Equipment, Wagon.

MISCELLANEOUS ARTICLES.	
Axes, felling, 4½ in. handles	2
,, pick, 6½ in. ,,	2
Bag, canvas, for flags	1
Basins, wash-hand, zinc, 11 in.	5
,, for washing sores, enamelled	5
,, soup, pint, enamelled	40
Bed covers, waterproof	25
Billhook	1
Blankets, hospital pattern, grey	50
Box, for money and valuables	1
Brushes, hand scrubbing	2
,, shaving	2
,, washing	6
,, whitewash	2
Buckets, water, galvanised iron	2
Cases, oil, feeding	1
Cans, soup, 3 gallons	2
Cases, palliasse, barrack pattern	50
,, bolster, ,, ,,	50
Chisels, ripping	1
Choppers, meat	1
Clothes' line (yards)	80
Cocks, brass bit, ¾ in.	2
Combs, hair	5
,, small tooth	2
Corkscrews, folding	2
Cups, tin, pint	34
Dishes, meat, tin, 18 in.	3
Egg cups, pewter	10
Feeders, sick, earthenware	3
Filter, water	1
Flags, white, with red cross, large	1
,, ,, ,, ,, small	2
,, national	1
Flagstaff, 18 ft.	1
,, 9 ft.	2
Forks, carving, large	1
,, dinner	50
,, flesh	1
Funnels, tin, ½ pint	3
Gowns, blue serge, lined	5
Hammers, claw, 20 oz.	1
Kettles, nests of 8	2
Knives, carving, large	1
,, for opening tins	2
,, dinner	50
,, butcher's	3
Ladles, pint, iron tinned	1
Lamp, distinguishing, external	1
Lanterns, hand, half-round	2
Matches, wax	1,000
Measures nests, ¼ gill to 1 qt.	1
Mill, coffee	1
Needles, packing	6
,, sewing, No. 6	24
,, ,, No. 7	24
Pans, bed, zinc, pewter handles	4
,, frying, 12 in.	2
Pepper castors	1
Plates, tin,	50
Pots, chamber, metal	6
,, spitting	6
Rags, linen (lbs.)	15
Razors	2
,, strop	1
Saws, cross-cut, 5 ft., leather case	1
,, hand, and leather case	1
,, butcher's, 14 in.	1
Salt cellars, wooden	3
Scissors, haircutting	2
Scoops, hand, tin, ½ pint	2
Shapes, pudding, pint	6
Sheets, linen	120
Shirts, cotton	12

Shirts, flannel	12
Skewers, iron, with chains	3
Slippers, brown leather, pairs	12
Socks, woollen, pairs	25
Spades, helved	2
Spitting cups, zinc	6
Sponges, bath	2
Spoons, table	50
Steel, butcher's	1
Stools, camp	2
,, close, metal and frames	3
Stretchers, new pattern, with pillows	2
Table, officer's camp, folding	1
Thread, packing, 1 lb. balls	6
,, whited brown ,,	1
,, worsted, grey ,,	1
Towels, hand	55
Trousers, blue serge, lined, pairs	10
Urinals, pewter	4
Waistcoats, blue serge, lined	10
Warmers, stomach	2
Waterproof sheets, ground	25
Weighing machine and weights, grocer's	1
Ditto, meat and vegetables	1
Wick for lamps, flat, ⅝ in., yds.	2
,, ,, ,, round ,,	2

MEDICAL COMFORTS, &C.

Arrowroot	lbs.	40
Brandy	bottles	30
Essence of meat, Liebig's	lbs.	28
Mustard	,,	5
Oil, colza	galls.	3
Pepper	lbs.	5
Rice	,,	50
Salt	,,	20
Soap	,,	30
Sugar	,,	50
Tea	,,	6

Field-hospital pharmacy wagons.—These wagons contain all the surgical instruments, materials, appliances, dressings, and medicines, for the use of the field-hospital. They also carry a small supply of stimulants, medical comforts, and some cooking utensils. These are supplementary to the supplies of the same nature in the hospital equipment wagons. The pharmacy wagon is so arranged, that not only any description of article carried in it may be readily got at without displacing other articles; but also as to admit of medicines being compounded at it without the necessity of carrying the bottles, or cases, in which they are contained, away from the wagon. This is important in order to facilitate the work of the dispensers; to prevent articles from being taken away and mislaid; and also to economise time when the wagon itself has to be closed up and moved, which it ought always to be possible to do at a minute's notice. Each article has a special place assigned to it in one or other of the compartments of the wagon; and each compartment has a printed list of its contents attached to it. As the pharmacy wagons are not only the medical and surgical supply-wagons for the field-hospitals with the troops, but are also interchangeable with those which are used in the hospitals along the lines of communication with the base, it is necessary that the medicines and dispensing apparatus, as well as the surgical articles contained in them, shall be sufficiently varied and ample to meet the wants of all these establishments. The following is a list of the articles and their quantities, which each pharmacy wagon is designed to carry.

Contents of the Field-Hospital Pharmacy Wagon.

MEDICINES.

	lbs.	oz
Acaciæ gum. contrit.	1	0
Acid. aceticum	2	0
Acid. carbolic.	2	0
,, gallic.	0	4
,, hydrochloric.	0	8

Contents of the Field-Hospital Pharmacy Wagon—cont.

MEDICINES.	lbs.	oz
Acid. hydrocyan. dil.	0	2
,, nitric.	0	8
,, phosphoric. dil.	0	8
,, sulphuric.	0	6
,, tannic.	0	4
,, tartaric.	1	0
Alumen	2	0
Ammon. carb.	1	0
Antimon. tart.	0	8
Aquæ distill.	2	0
Argenti nitras	0	4
Atropiæ sulph. (in $\frac{1}{120}$ grain disks for hypodermic use) No. 250		
Bismuthi subnitr.	0	8
Bromum	0	8
Calomel	0	8
Camphora	0	8
Capsici pulv.	0	2
Catechu contrit.	0	8
Chiretta contus.	3	0
Chloral hydrate	1	0
Chloroform. 6 bottles	6	0
Cinchon. contus.	4	0
Collodium	0	4
Creasotum	0	4
Cupri sulph.	2	0
Empl. plumbi	2	0
,, saponis	2	0
Ergotine in $\frac{1}{2}$ grain disks, No. 250		
Extr. Belladon.	0	8
,, Filicis liq.	0	4
,, Hyoscy.	0	8
,, Opii	0	8
Ferri et quin. citr.	0	8
,, sulph.	0	8
,, perchlor.	0	8
Glycerinum	2	8
Hydrarg. bichlor.	0	2
,, c. cretâ	0	8
,, iodid. rubrum	0	2
,, nitrico-oxyd.	0	4
Iodini	0	4
Ipecac. contrit.	1	0
Liniment. saponis	2	0
Liq. ammon.	1	0
,, arsenicalis	0	8
,, epispasticus	0	4
,, sodæ chlor.	2	0
,, strychniæ	0	2
Magnesia	0	8
Magnesiæ sulph.	7	0
Morph. acet. (in $\frac{1}{6}$ grain disks) No. 1,000		
Morph. hydrochlor.	0	2
Ol. anisi	0	2
,, copaibæ	2	0
,, lini	12	0
,, menth. pip.	0	2

	lbs.	oz
Ol. olivæ	8	0
,, ricini	8	0
,, terebinth.	2	0
Opium contrit.	0	4
Pil. colocynth. et hyoscy.	1	0
,, hydrarg.	1	0
Plumbi acet.	2	0
Potass. bicarb.	1	0
,, bitartr.	1	0
,, bromid.	0	8
,, caustica	0	4
,, chlor.	1	0
,, iodidum	1	0
,, nitras	2	0
,, permang. crudum	14	0
,, ,, purum	0	8
Pulv. cretæ aromat. c. opio	4	0
,, ipecac. co.	0	8
,, jalap. co.	1	8
Quinæ sulph.	0	12
Rheum contrit.	0	8
Salicine	0	12
Senegæ rad.	3	0
Sennæ fol.	3	0
Sodæ bicarb.	2	0
Spir. ætheris co.	1	0
,, ,, nitrosi	1	0
,, ammon. aromat.	1	0
,, chloroformi	1	0
,, rectificatus	2	0
Strychniæ (in $\frac{1}{6}$ grain disks) No. 250		
Sulphur sublim.	2	0
Tinct. aconiti	0	8
,, aurantii	0	8
,, capsici	0	8
,, cardam. co.	1	0
,, catechu	2	0
,, colchici sem.	0	8
,, digitalis	0	8
,, ferri sesquichlor.	1	0
,, ergotæ	0	4
,, hyoscy.	1	0
,, iodi	1	0
,, lobeliæ	0	8
,, myrrhæ	0	8
,, opii	1	0
,, rhei co.	1	0
,, scillæ	1	0
,, sennæ co.	1	0
,, valerianæ	0	8
Ung. cetacei	28	0
,, hydrargyri	2	0
,, ,, nitr.	2	0
,, resinæ	2	0
Zinci chloridum	0	8
,, oxidum	0	8
Zingiber contrit.	0	8

Contents of the Field-Hospital Pharmacy Wagon—cont.

DISPENSING APPLIANCES, &c.

Bolus tiles, 10 in.	No.	2
Bottles, 4 oz.	,,	18
,, 8 oz.	,,	12
Boxes, chip	papers	1
,, paper	,,	2
Corks, assorted	gross	1½
Corkscrew, folding	No.	2
Funnel tin, ½ pint	,,	1
Gallipots, nests of 4	,,	5
Labels, blank	,,	200
Measures, glass, minim	,,	2
,, ,, 2 oz.	,,	1
,, ,, 10 oz.	,,	1
,, pewter, 1 oz.	,,	1
,, tin, pint	,,	1
Mortar and pestle, small	,,	1
,, ,, medium	,,	2
Paper, wrapping	quire	1
Pill machine	No.	1
Scales and weights, grain, small	,,	1
Scales and weights, grain, large	,,	1
Scales and weights, stand for	,,	1
,, ,, ounce	,,	1
,, ,, stand for	,,	1
Spatulas, small	,,	1
,, ordinary	,,	3
,, spreading	,,	1
Stopper loosener	,,	1

SURGICAL INSTRUMENTS.

Amputating case	No.	1
,, knives, spare set	case	1
Bandages for bloodless operations	,,	1
Catheters	,,	1
Cauterising irons	No.	3
Chloroform inhalers	,,	2
Cupping instruments	case	1
Dressing cases for Orderlies	No.	5
Eye instruments	case	1
General case of instruments	No.	1
Gypsum bandage case	,,	1
Hypodermic syringes	,,	3
Ophthalmoscope and laryngoscope case	,,	1
Pocket case	,,	1
Post-mortem case	,,	1
Resection case	,,	1
Stomach pump	,,	1
Transfusion apparatus (Roussel's)	,,	1

DRESSING MATERIALS.

Bandages, calico, 1½ in. wide, 4 yards long	No.	200
Bandages, calico, 2½ in. wide, 7 yards long	,,	288
Bandages, calico, 3 in. wide, 8 yards long	No.	240
Bandages, flannel, 4 in. wide, 8 yards long	,,	50
Calico	yds.	50
Carded cotton	lbs.	6
Flannel	yds.	20
Iron wire, plated	oz.	2
Leather skins	No.	6
Ligature, catgut, carbolised	oz.	2
,, silk	,,	8
Linen	yds.	30
Lint	lbs.	70
,, marine	,,	36
Oiled silk	yds.	6
Pins	oz.	8
Plaster, adhesive, Leslie's cases, containing 12 ½-in. tapes, each 12 yds.	No.	6
Plaster, adhesive, Leslie's cases, containing 6 1-in. tapes, each 10 yds.	,,	12
Plaster, adhesive, Leslie's cases, containing 1 6-in. tape, each 14 yds.	,,	6
Plaster, gelatine	yds.	20
,, soap	,,	24
Sponges, surgeons'	No.	36
Tape, broad	pieces	6
Tow, surgeon's	lbs.	40
Waterproof cloth, German	yds.	30
Wax for ligatures	oz.	2

SURGICAL APPARATUS AND APPLIANCES.

Air cushions	No.	6
Arm cushions, Stromeyer's	,,	6
,, slings	,,	6
Brackets, iron, galvanised and screw	,,	6
Fracture apparatus, assorted, viz:—		
Thigh, long splints, with pads, &c.	sets	6
Thigh, long splints, with foot pieces, &c.	,,	2
Thigh, Smith's anterior	No.	2
Knee-joint, flannel, for plaster of Paris	,,	4
Leg and ankle, scored splints and pads	sets	3
Leg and ankle, scored, 19 in. pads	,,	3
Leg and ankle, iron, with pads, right	,,	3
Ditto, left	,,	3
Leg and ankle, flannel, for plaster of Paris	No.	6
Leg and ankle, McNalty's splints	,,	3

Contents of the Field-Hospital Pharmacy Wagon—cont.

Fracture apparatus—			Matches, wax	No.	1,000
Arm, scored splints, 9-in. and 11-in. pads . .	sets	8	Needles, packing . . .	,,	4
Arm, scored splints, 10-in. and 12-in. pads . .	,,	8	,, sewing . . .	,,	25
Elbow, hinged splints .	No.	3	Oil, colza	pints	6
Forearm, scored splints, 13 in. pads . . .	sets	3	,, mineral, paraffin . .	,,	8
Forearm, scored splints, 14-in. pads . . .	,,	3	Operating table . . .	No.	1
Forearm, scored splints, 15-in. pads . . .	,,	3	Packthread	lbs.	1
Wrist and hand, palmar splints	,,	8	Pencils, blacklead . .	No.	2
Gutta percha, 18 × 4 × $\frac{3}{16}$ in.	pieces	12	Pens, steel	boxes	2
Indiarubber tubing, drainage	yds	18	Penholders	No.	4
Irrigators and tubing, nest of 3	set	1	Ruler, 12 in., ebony . .	,,	1
Plaster of Paris . . .	lbs.	30	Scissors, counter . . .	pairs	2
Pulleys, &c., for counter-extension	No.	6	Stethescopes, vulcanite .	No.	2
Steel trusses, reversible .	,,	4	Syringes, enema, pewter .	,,	1
Suspensory bandages . .	,,	6	,, urethra, glass .	,,	6
Waterglass	lbs.	2	,, ,, pewter .	,,	12
			Test-paper, litmus . .	books	24
			,, turmeric . .	,,	12
			Test tubes, nests of 4 . .	No.	6
			Thermometers, bath . .	,,	1
			Thread, sewing, white | brown	oz.	4
			Urinometer	No.	1
			Wick cotton, $\frac{3}{8}$ in. for colza oil	yds.	2
			Wick cotton, $\frac{7}{8}$ in. mineral oil	,,	1

SUNDRIES.			MEDICAL COMFORTS, &c.[1]		
Bandage roller . . .	No.	1	Arrowroot	lbs.	9
Basins, zinc, 11 in. . .	,,	2	Brandy	bottles	18
Camel's hair brushes . .	,,	4	Essence of beef, Liebig's .	lbs.	20
Cover-tent for dispensing table at rear of wagon .	,,	1	Mustard	,,	3
Hone	,,	1	Pepper	,,	3
Ink bottles	,,	2	Rice	,,	20
,, eraser and indiarubber .	,,	1	Salt	,,	14
,, powders	,,	2	Sugar	,,	20
Lamps, hand, half-round .	,,	2	Tea	,,	3
,, operating . . .	,,	1	Kettle, 2 gallon . . .	No.	1
			,, cooking, nests of 4	,,	1

Other field-hospital wagons.—The remaining stores, such as the hospital tents, officers' baggage, bedsteads (whenever they form part of the equipment of a field-hospital), and other such bulky articles, do not require any special construction of the vehicles by which they are conveyed. They can be as efficiently carried and as well protected in general service wagons as in any other conveyances.

Hospital tents.—Two kinds of tents have been generally used in British field-hospitals, hospital marquees and bell tents. The marquee is by far the heaviest, its weight, when dry, being 500 lbs. It is arranged for accommodating eighteen patients. Marquees never formed part of the regular equipment of field-hospitals until

[1] Note. Though the necessary space and tins are provided for these articles, in order to save weight, it is not intended they shall be carried unless under very urgent circumstances.

after the recommendations of the Royal Commissioners who were appointed to inquire into the organisation of military hospitals, subsequently to the Crimean War. The soldiers' bell tent was generally supplied for the use of the sick in the field-hospitals. It was made of single canvas, and was comparatively small in dimensions, so that many practical inconveniences attended its employment for hospital purposes. They were thus summed up by the Royal Sanitary Commissioners: 'The bell tents are hot in summer, wet in autumn, cold in winter; unpleasant from their insecurity and waving movement in windy weather; too confined for the performance of professional duties; ill-adapted for the nursing of sick men; and far too limited on the floor to enable medical officers to render patients in any degree comfortable.'[15] And all these inconveniences became serious evils when the bell tents became old and threadbare from long service, as the tents were which were issued to the army in the Crimea during the winter of 1854-55. On the other hand, as supplementary to fixed hospitals, or for forming reserve hospitals, or when troops are posted in a standing camp, or halt for a few days when marching, marquees can be made very comfortable for patients. From being double, and from there being a space between the outer wall and the lining, they are, as described by the Commissioners before-mentioned, 'temperate in hot weather, dry when it rains, moderately comfortable during the prevalence of high winds, while they afford greater shelter than bell tents against cold, enable medical officers to approach the patients with more comfort to themselves, and permit the orderlies to attend better to the wants of the sick.' Hospital marquees have been much improved in their construction of late years, especially with respect to light and ventilation.

The bell tent has always been a useful part of the hospital equipment, however, when it has been employed as an adjunct to the marquee, on account of its lighter weight, and the consequent facility with which it could be raised or packed up again. The modern circular tents are far superior to the old bell tents in form, height of walls, protection, interior space, and ventilation. There are two kinds, the circular tent and the double circular tent. The former, complete with its pole, weighs 74 lbs. when dry; the latter, 100 lbs. Like all canvas tents, they increase about one-fourth in weight when wet. Four patients may be placed in the double circular tent.

Hospital servants should be well trained in pitching and packing hospital tents of all kinds with celerity; their employment will frequently depend upon the ability of the hospital orderlies in this respect. If the orderlies are not well trained, so that they are likely to be awkward, and to occupy a long time, in pitching and striking them, surgeons will hesitate to use them on many occasions, lest the probable delay in getting them ready and

packing them up again may interfere with the movements of the hospital and do more general harm than good to the sick.

Tent for surgical operations.—Two of the double circular tents, without lining, form part of the equipment of a bearer company for use as operating tents. In standing camp hospitals, when circumstances admit of the proceeding, a circular bell tent may be easily turned into a very convenient operating theatre, both as regards the patient, and also as to space for the surgeon, his assistants, and the attendants. For this purpose the central pole of the tent is to be removed, and, instead of it, three poles of about the same height are made to support the tent, their lower ends resting upon a ledge just within the tent curtain. The whole floor of the tent is thus left free. This is now sunk by excavating it all round sufficiently for the surgeon and his assistants to stand well upright within the slope of the tent. A part of the earth is left untouched in the centre, of convenient size and shape to serve as a table, which may be suitably covered for supporting the patient.

Field bedsteads.—Bedsteads are really very necessary articles for protecting patients from the deleterious influences to which they are exposed when they are laid upon floors in houses, or on the ground in tents. At the same time, as ordinarily constructed, they are too heavy an incumbrance to be included in the general equipment of field-hospitals. Some impromptu substitutes have often to be employed, therefore, for regular bedsteads in campaigning.

Former Army Medical Regulations [16] showed that temporary bedsteads might easily be constructed in the field for patients in a short space of time, and at a trifling expense. Some faggotwood, drawn from the commissary by requisition, with a few nails are all that are required for the purpose. These contrivances are especially required at intermediate hospitals when the sick are placed under canvas, or are accommodated in the barns or outhouses of a farmhouse or other detached building. The sketch on the next page (fig. 46), of the field bedstead recommended, and the following description of the mode of putting it together, are quoted from the regulations referred to above.

Temporary field bedstead.—'This temporary bedstead is formed by two rows of stakes driven into the ground, rising fourteen inches above the surface, and standing ten inches asunder. The width of the frame must be determined by the bedding, and the number of stakes by the necessary length. The cross rails are made of the same materials split asunder, with the flat side upwards, and the ends properly prepared for the nails; but it is to be observed that the head rail which supports the bolster is to be placed on stakes six or eight inches higher than the others. Between this frame and the palliasse a suitable defence of a mat or mats of straw is to be interposed.'

When wounded men are laid upon straw palliasses, each palliasse should be kept from touching the floor or ground by means of hay or straw, or, better still, by straw mats placed underneath. The art of making straw mats is soon acquired by soldiers. The patient can then be shifted from his place, without much disturbance, lying on his palliasse, while the hay or straw underneath is aired and dried; or, if necessary, removed altogether to be replaced by fresh straw or hay. The mattresses that are found in country houses usually consist of closely woven ticking containing densely packed and matted wool, fastened together in such a way that it

FIG. 46.

Temporary Field Bedstead.

admits of but little shifting. Such articles ought never to be used as beds for wounded men. They absorb and hold moisture of all kinds with great facility. Blood or purulent discharges that find their way to them are readily soaked up, and soon become more or less fetid. They cannot be cleaned or dried without much trouble and expenditure of time. A straw pallet, on the other hand, can be shaken up and aired without difficulty; and, if discharges find their way into it, the cover can be washed and disinfected, the straw burned, and another supply obtained.

Concluding remarks on field-hospital equipment.—However liberal the hospital supplies and equipment may be at the starting of an expedition, it is well to bear in mind that, in spite of all precautions, the casualties of war will sometimes deprive the troops of their presence. Army medical officers should therefore be prepared to take advantage of any means which can be made to serve as substitutes for them. One of the traits of character which particularly made the eminent Baron Larrey so highly esteemed by that great judge of character, and quick observer of special usefulness in particular spheres of duty, the first Napoleon, was his remarkable fertility of resource in promoting the interests of his wounded patients. Larrey has recorded regarding the first great encounter in the Russian campaign of 1812, the battle of Smolensko—where the French admitted they had 1,200 killed and

6,000 wounded among themselves, and described the number of killed and wounded left by the Russians to be incalculable—that the French surgeons found themselves destitute of all means of dressing their patients. They therefore, under Larrey's direction, made use of the paper found in the Government Record Office, which was occupied as a hospital, instead of lint. For charpie they substituted tow and the cotton of the common white birch. Paper even was spread as bedding for the patients to lie upon, for no straw or other suitable materials were to be obtained: all the furniture of the city had been pillaged and carried away, or was destroyed by the fire which consumed a great number of the houses.[17] At another time, in Syria, when there was a want of butcher's meat to make broth for the wounded, Larrey, with the approval of the general commanding the division, sacrificed a number of camels for the purpose. When this resource failed, he used horse-flesh. As a substitute for salt gunpowder was employed, the nitre in it taking the place of the ordinary salt. The great Robert Jackson, whose writings are most worthy of perusal by all army medical officers, was made a prisoner during the American War of Independence, when he was serving in the 71st Regiment. He at once occupied himself in aiding the wounded, and no materials for dressings being at hand, he took off his shirt and tore it up into bandages.[18] Swords, bayonets, firearms, bits of branches from a tree, strips of uniform taken from the dead, pocket handkerchiefs, and other such extempore means, have not unfrequently been turned to account in place of regular splints and bandages, and, when judiciously applied, have supported broken limbs during the conveyance of wounded men from a field of action almost as efficiently as the best apparatus specially designed for the purpose. It is vain to expect to obtain in the field all the numerous appliances and instruments which are to be met with in a civil hospital in the midst of a civilised community. Yet some would appear to expect to find them there on all occasions and under all circumstances. It is stated in a summary report written by an eminent French surgeon, of the surgical operations performed in the field during the Italian campaign of 1859, that the insignificant number of resections of joints must not be attributed to a voluntary abandonment of the operation, but that it was owing to the fact that the resection instruments did not reach headquarters until a week after the terrible battle of Solferino.[19] But every surgical instrument case will surely contain a scalpel and a narrow saw, and, with these instruments alone, any resection ought to be undertaken rather than unnecessarily sacrifice a limb by amputation. The mind of the military surgeon should be trained to making himself familiar with such expedients. In this way, whenever professional difficulties of the kind above indicated arise, a good field surgeon will be ready to prove his superiority by

exhibiting aptitude in turning to account every available resource for overcoming them; while, under the same circumstances, a less energetic and competent medical officer will be paralysed on finding himself without the particular aids and appliances to which he has been accustomed.

CHAPTER IV.

SICK-TRANSPORT EQUIPMENT.

Preliminary observations.—I propose, in the present chapter, to confine my remarks principally to a description of the conveyances which are sanctioned for use in the British service. I have already discussed, in a work on the 'Transport of Sick and Wounded Troops,' most of the general questions connected with the removal of patients from place to place in time of war; and I have also described in it the most important kinds of sick-transport vehicles which, at the time of its publication (1869) were in use in the armies of different countries. Since that date increased attention has been given to the subject, and many improvements have been made in sick-transport vehicles, in almost all civilised countries. Prolonged and searching experimental inquiries have been instituted during this period as to the forms of ambulance vehicles best adapted for use in the British military service, and considerable changes in the construction, which had been previously authorised for them, have been the result. The new forms only will be described.

The different classes of conveyances have not been changed. They consist, as before, of (A) Stretchers; (B) Wheeled stretchers; (C) Mule litters and cacolets; (D) Ambulance wagons; and (E) Railway ambulance trains. No final arrangements have yet been made for adapting British railway vehicles to convey wounded in time of war; but attention has been given to the subject, and one system of converting certain classes of railway vehicles into ambulance conveyances has met with much approval. An account of the plan referred to will be given after the other forms of ambulance conveyances have been described.

(A.) *Stretchers.*

General remarks on stretchers.—A stretcher is a conveyance consisting of two wooden side-poles, furnished with handles, and having between them a canvas support on which a patient can be carried in a recumbent position. This latter part—the bed—is maintained sufficiently firm by the stretching action of cross pieces of wood or iron, called the *traverses*. It is from the traverses, or stretchers, that the whole conveyance gets its name. A stretcher

is generally furnished with four foot-pieces, so that, when the stretcher is laid on the ground by the bearers, the patient lying on the canvas may not be subjected to the effects of damp, or to pressure from stones or other irregularities of the surface.

A combination of many qualities is necessary to constitute a good ambulance stretcher. It must be as light as practicable, so that it may be easily carried; strong enough to resist shocks from rough usage; its poles and traverses must be sufficiently rigid, without undue bulk, to maintain their straightness and to prevent the canvas from sagging when a man is placed on it; it must be capable of being folded up, to economise space in stowage; it must have a firm, but not hard, support for the patient who is to be carried on it; and it must be economical in cost, on account of the large number required in the field. For an army of 60,000 men, it has been calculated that 2,000 stretchers are wanted; being at the rate of 32 for each thousand men, with a moderate margin for losses and breakages.

A wounded man may be carried on a stretcher by two bearers, but, if the distance be long, a third becomes essential, to act as a relief during the transport, and to assist the patient on the way. Bearers require to be specially instructed in the duty of carrying stretchers. It makes all the difference between comparative ease on the one hand and aggravated suffering on the other, between almost complete escape from further injury and serious risk to life, whether wounded men—especially men with bones fractured by gunshot and others with grave internal injuries—are placed and carried on stretchers by trained or untrained bearers.

Time occupied in carrying patients on stretchers.—Some experiments were made at Netley to determine the time occupied by trained bearers in removing wounded men on stretchers. It was found that to remove the accoutrements from a soldier, to carry him, his rifle, and accoutrements, a distance of a measured mile over moderately rough but still level fields, and to lift him off the stretcher, occupied 26 minutes. Three men were employed as bearers; each, in turn, acting as a relief to the two men carrying the stretcher. They halted and changed eight times in the course of the mile. The time occupied in returning with the empty stretcher was 18 minutes. Thus the total time occupied by the three bearers in carrying a patient a mile, and returning, was 44 minutes. Had it been necessary for the bearers to attend to a wound in the first instance, in addition to removing accoutrements and releasing the clothes of the patient, the time occupied would have probably been a full hour; and it hardly seems safe to depend upon bearers transporting a wounded man a mile, and returning to the place from which they started, in less than that time. The stretcher used in the experiment was the new pattern ambulance stretcher which is described in the following remarks.

Description of the new pattern stretcher.—An important improvement has been effected in the ambulance stretcher lately introduced for use in the British service. There were formerly two kinds of stretchers—one for carriage by hand, the other for special use in ambulance wagons. Thus, a wounded man, on being transferred to the wagon, would have to be lifted off the hand-stretcher in order to be placed on the wagon-stretcher. These have now both been made alike, so that they are interchangeable. The stretcher in the wagon can be taken out, and used as a field stretcher; and the stretcher on which a wounded man has been carried from the field, can be lifted and put into the wagon in its place. The painful disturbance to the wounded man of a change from one to the other is thus avoided. This advantage has been gained, however, at the expense of some additional weight.

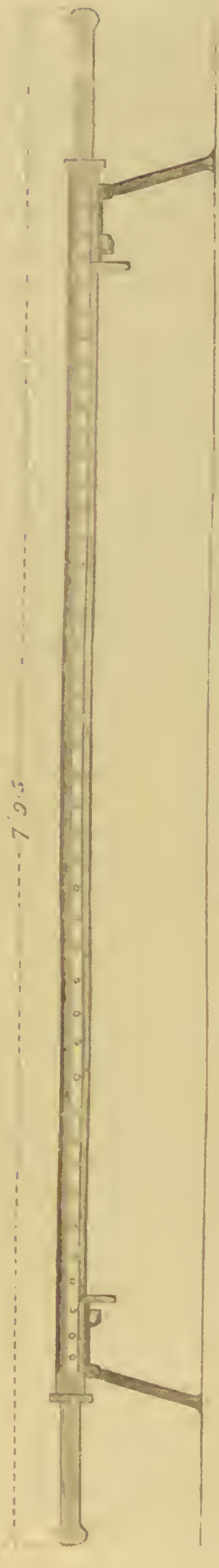
The stretcher of the new pattern consists of a piece of stout tanned canvas 6 ft. 6 in. long, by 1 ft. 11 in. wide, nailed with brass nails through an edging of leather to two ash side-poles, each measuring 7 ft. $9\frac{1}{2}$ in. in length. They are $1\frac{3}{4}$ inches square in the middle, but taper slightly towards the handles. The lower edge of the side-pole is rectangular; the upper surface is rounded. Two leathern collars are secured to each of them at the termination of the canvas; these were added in order to adapt the stretcher for insertion in the ambulance wagon. There are also two small leathern stops near the middle of each side-pole; they indicate the part at which the stretcher is to be placed on the wheeled support when it is to be used as a wheeled stretcher. The traverses are permanently attached to both side-poles. They consist of two flat steel bars, each one inch in width, $\frac{5}{16}$ths of an inch in thickness, and hinged in the middle. The hinge is secured by a steel binder slipping over it. The feet, four in number, are made of iron, are single-hinged, and are enlarged at the lower end to prevent them from sinking into the ground, from which they raise the stretcher six inches. The weight is $25\frac{1}{2}$ lbs. The whole contrivance is arranged so as to fold up readily for packing; and no part of it is separable, or liable, therefore, to be missing when the stretcher is required for use.

Each stretcher has eyelet holes to enable a pillow to be fastened to it by strings; but pillows are only intended to be used with stretchers in ambulance wagons, in each of which two are kept for the purpose. In carrying a wounded man from the field, if it be necessary to raise his head on the stretcher, it can be done by placing the man's valise or great coat under it.

The drawings, figs. 47 and 48, exhibit a side view of the stretcher and a half plan of its two surfaces.

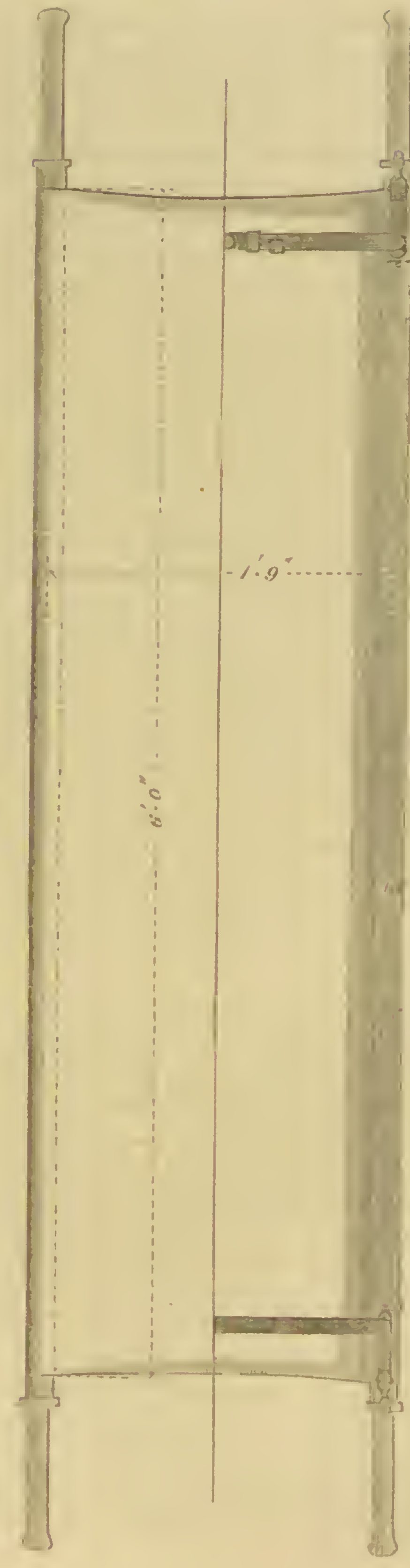
A change in one of the details of construction of the stretcher has just been ordered. Gun-metal rollers are to be fitted to all the feet. These latter are to be kept rigid when down, and permitted to fold up when required, by altering the position of the pin in the

FIG. 47



Side view of the Regulation Stretcher, with measurements.

FIG. 48.



Half plan of upper and under surfaces of the Regulation Stretcher with measurements

hinge, which is to be arranged for effecting this purpose without its removal being necessary. The stretcher will thus be rendered capable of being easily pushed into the regulation ambulance wagon, or any wagon with a level floor, on its own rollers. The weight of the stretcher will not be increased by the addition of the rollers, as they cause the leathern collars on the side-poles to be no longer needed, and they will be removed. In connection with this alteration of the stretcher, it is intended to make a change in some of the fittings of the ambulance wagon: these will be noticed when the wagon is described.

Shoulder slings, that is, leathern straps, or bands of webbing, which are made to rest across the shoulders of the bearer and to terminate in two loops into which the handles of the stretcher can be inserted, are useful in helping bearers to carry stretchers. They enable the bearers to take off part of the strain upon the hands and arms, and occasionally to relieve them of it altogether. They also add to the security of a patient while being carried on a stretcher. The stretcher cannot be so readily dropped, in case of a bearer being weak or careless, when it has the additional support of a shoulder sling. The hospital conveyance committee recommended that shoulder slings should form part of the equipment of all bearers. They were led to adopt this recommendation, as experience had shown that shoulder slings are apt to be lost when issued with stretchers: and it was supposed that this would not be so likely to occur if the bearers were made responsible for them. Dr. Sandford Moore, instructor of the Army Hospital Corps, has, however, devised a plan by which they may be fixed to the stretchers: thus avoiding risk of losing them, and, at the same time, admitting of their being turned to account in strapping the stretcher together when it is folded up.

Manner of removing patients by stretchers.—Some years ago I published a paper on the carriage of wounded men on stretchers, and other similar hand-conveyances. As the 'Army Medical Reports' in which the remarks appeared,[20] are in the hands of but a very limited circle of readers, and as the manner in which stretchers are used is of the utmost importance to the patients who have to be carried upon them, I insert here some of the rules, and a portion of the observations, which were contained in the paper referred to. Some of them will equally demand attention, whether an injured person be carried by hand on a shutter or any other substitute for a regular stretcher, but the use of stretchers by trained bearers is chiefly kept in view.

The main objects to be aimed at in carrying these conveyances are, firstly, that as little as possible of the impulse connected with the progression of the bearers shall be communicated to the stretcher which they are bearing; and secondly, that the conveyance may be kept level, and as near the ground as is consistent with

free carriage and the absence of risk of contact. If one of these conveyances be badly carried, it may be shaken in such a way by the movements of the bearers as they step along, that the patient may be rolled upon it from one side to the other alternately. Again, it may have such a motion communicated to it that the patients may be jerked *upwards* with every step; or the patient may be so placed that his head is lower than his feet, or his body may be unevenly supported, in either of which cases the ill results of the movements just described will be felt with more severity. The conveyance, again, may be raised so high that the patient upon it may be kept in constant apprehension of falling off; or, in case of one of the bearers accidentally stumbling and allowing the conveyance to fall, he may receive such additional injuries as to lead to serious consequences. All these objectionable movements and wrong positions, which would be irksome enough to men in sound health, entail serious suffering and risks to men who are labouring under fractures of bones or other severe wounds. Fortunately this suffering may be, in a great degree, prevented by a systematic observance of the rules hereafter mentioned, whatever the circumstances of the locality, or whatever differences there may be as to height or strength among the bearers.

One of the first things to impress upon bearers is that every movement of a man who has just been wounded must be made with considerable care and gentleness, to prevent pain and aggravation of his injuries. Care when raising him from the ground, where he has fallen; when placing him upon the stretcher; when lifting the stretcher with the patient upon it; when halting and laying it down for the purpose of resting; in each of these cases, care is as essentially necessary to obviate suffering and additional mischief, as is a properly regulated step during the transport itself.

Very particular precautions are required when a patient has had a bone recently shattered by gunshot. The proper manner of accomplishing the delicate task of lifting and removing a man with such an injury, the various modes of protecting the broken limb during the transport, are subjects in which all bearers of wounded require to be specially instructed.

It has been usual in the British Service to tell off only two men to every stretcher. For several reasons, however, it is most desirable that three men should accompany every stretcher which is used for carrying a wounded man from a field of action. The third bearer is required in case of either of the other two bearers becoming wounded, to assist in placing upon the stretcher any man who has been rendered quite helpless by his wounds—especially one who has met with a serious fracture of bone from gunshot—and to act as a relief to one or other of the bearers who may become fatigued during the transport. A patient with a fractured thigh or leg should never be lifted up and put on a stretcher by two bearers

only, unless under extreme urgency. The position of a patient after he is on a stretcher, too, both on starting and during the transport, frequently requires rectification, owing to displacement from sagging of the canvas, or from the effects of movement during the carriage; and this can only be done, without laying the stretcher down on the ground, when a third bearer is present.

Before attempting to remove a badly wounded man from the spot where he has fallen, the stretcher should be brought close up to him; the wounded man should not be carried by hand farther than can be avoided. In placing the stretcher for this purpose, it *should not be laid by the side of the patient*, but at his head; and should not be placed crosswise, but the length of the stretcher should be in the same direction as that in which the wounded man happens to be lying. If placed by his side it interferes with the movements of the bearers in lifting him up, necessitates their moving to the end of the stretcher, or stepping across it, and is liable to cause them to stumble when they are depositing the patient upon it. If placed crosswise at the patient's feet, it leads to the necessity of the bearers turning round, and again causes the risk of one or other of them falling over the side-poles. These objections are avoided by the stretcher being placed longitudinally; the patient is readily carried head forward over the canvas on which he is to lie, and the bearers move with a clear view of the stretcher before and between them, until the patient's head is directly over the pillow on which it is to rest.

The bearers told off for carrying stretchers in military service should be severally distinguished by some ready appellation, and one must invariably take the direction of all the duties connected with the transportation of a patient, if they are to be properly performed. The bearer who marches foremost is usually designated the front, or No. 1, bearer; the one who is behind, the rear, or No. 2, bearer. If a third bearer is told to assist in the transport, he is designated No. 3 bearer. The rear, or No. 2, bearer must assume the direction, for his position enables him to see not only the patient on the stretcher, but the front bearer also; while the front bearer cannot see either, but only the ground or other objects before him. There are certain parts of the process which should always be conducted by short words of command; these are especially, lifting up a wounded man and placing him on the stretcher; the start; and laying down the stretcher. The object is not so much to ensure the alert and sharp movement which is required in military exercises as it is to ensure, without loss of time, the necessary caution, steadiness, and well-concerted action of the bearers.

Lifting up and placing a wounded man on a stretcher.—As soon as all essential attention has been paid to the general condition of the patient, or to the particular injury he has received—when the

necessary prevention of movement of a limb, if a bone be broken, by any available support at hand; the preparation of supports on the stretcher itself, if needed for the injured part, by arranging the man's clothing and accoutrements for the purpose; and all other such matters, which, it is presumed, the sick bearers are familiar with, have been attended to—the next proceeding is to place the patient on the stretcher.

With three bearers, this is best done by two of the bearers stooping down on opposite sides of the patient, near his haunch-bones, the two bearers facing each other. The third bearer places himself in a stooping position near the wounded part of the patient, ready to give to it his undivided attention. The two bearers facing each other gradually get, each one hand, under the back of the patient, their other hands being passed and mutually grasped under the upper part of his thighs, as close to his breech as possible, while the third bearer at the same time takes charge of the injured part. As soon as this is done, the bearer who takes the direction gives the word 'ready.' At this word the bearers secure a firm grasp of the patient. The order 'lift up' follows. Immediately, all the bearers, acting together, slowly rise from the stooping posture, and, bringing their knees together, stand up. As soon as the erect position is gained, the order is given to 'march.' The bearers march until the patient is exactly over his place in the litter, and the order 'down' being then given, he is carefully lowered, and deposited upon it.

The start.—The start in every instance will be best accomplished by dividing the action into four parts, and assigning to each its distinct word of command. As soon as the patient is properly settled upon the stretcher which is lying upon the ground, No. 2 bearer gives the word 'fall in.' At this command Nos. 1 and 2 bearers get into their proper positions at the head and foot of the stretcher, and No. 3 by the side of it. As soon as this is done, No. 2 bearer gives the word 'ready.' The two bearers at once adjust the ends of the shoulder-straps, and take hold of the handles of the stretcher-poles. This being done, No. 2 bearer gives the word 'lift,' and immediately the two bearers raise the stretcher steadily together. No sooner is the stretcher raised, and all is seen to be right, than the word 'march' is given by No. 2 bearer, and both bearers at once move off.

Laying down a stretcher with a patient upon it.—In like manner, when the stretcher is to be lowered and placed on the ground, it will be best done by corresponding divisions of the action and words of command. No. 2 bearer calls 'halt,' at which both bearers stop, but without any abrupt or sudden jerk; the word 'ready' is then given, which is the signal for getting into position to stoop; the word 'down' follows, when the stretcher is lowered, and laid gently on the ground; and lastly, at the

word 'fall out,' the two bearers quit their hold of the handles, and move away from the stretcher.

A systematic performance of these duties in the manner described is easily acquired, and, when the bearers are trained to it, is calculated to prevent many a mishap, and to lessen the pain to wounded or sick men on all occasions. Every bearer should be trained to take the position of a No. 1, 2, or 3 bearer: his services may be required on the moment in any one of them.

Some general rules on the carriage of stretchers follow:—

Rule 1. The front and rear bearers of the conveyance must start with opposite feet. They must not move 'in step,' but, on the contrary, must march out of step, or, as the ordinary expression is, must 'break step.' If the man in front step off left foot forward, the man in the rear must step off at the same moment right foot forward, or *vice versâ*, and this broken step must be maintained throughout the whole distance of the transport.

It is not an easy matter at first to enforce this rule among men who have been serving in the ranks of the army; indeed, it is only by systematic instruction and practice that the proper method of carrying a stretcher can be acquired by them. The art of marching in broken step is one of the first lessons to be taught in the instruction of soldiers whose duty it will become to carry sick and wounded on stretchers.

The reason which dictates the rule I have just named is readily apparent on examination. If two men carrying a stretcher between them keep step in starting, as a front and rear rank soldier do in commencing to march, that is, if both men advance their left foot together, there must at the same time be a downward inclination of the body of each man towards the same side in proportion to the distance to which his foot is advanced, and equally so of the stretcher which they are carrying. When next the right feet are advanced together, the inclination will be changed from the left to the right side; and this alternate change of inclination will be unavoidably communicated to the wounded man lying upon the canvas stretcher, and will be continued so long as the step is kept. The wounded man is placed in much the same circumstances, as regards the kind of movement to which he is subjected, as a man who is riding on a camel; instead of being, as he should be, in the position of one on the back of a horse when the animal is walking. But when the step is broken at starting, that is, when the front rank man advances his right foot, and at the same time the rear man advances his left foot, as the horse does his opposite feet in walking, the dipping motion down to either side is avoided, and the surface of the stretcher is maintained on a horizontal plane. With each step of the bearers there is a moderate upward and downward movement of the

stretcher, chiefly owing to the pace of the men and to the elasticity of the side-poles: but, with this exception, the general level is preserved. There is no lateral movement giving the patient a tendency to roll from side to side.

The rule equally applies if the stretcher be carried by four instead of by two men. The step must be broken by the front and rear rank men, so that the level of the stretcher may still be preserved.

RULE 2. The bearers must march with a steady but easy step, particularly avoiding elevation of their bodies by springing from the fore part of the feet. The foot should be planted without any wavering on the ground at each step, and, in moving forward, it should only be raised sufficiently to clear the ordinary impediments on its surface. Some bearers, unless this rule is enforced, will make a slight spring at each advance, and this is of course communicated to the more or less pliable conveyance they are carrying. They do so in the belief that the weight is sustained more easily in consequence of the elastic movement which is thus obtained, but they take no note of its ill effect on the person who is being conveyed by them.

The length and kind of step best suited for bearers.—In carrying a stretcher the pace should not be so long as it is in marching in the ranks, and the movement of the lower limbs should be conducted on different principles. When a combatant recruit is under instruction he is taught, in practising the balance step, which forms the foundation on which the art of marching is built up, that the knee should be kept stiff, and the whole limb straight, when it is either advanced in front or extended behind. The movements of his lower extremities are all to be from his hips. The toe of his foot is to be advanced, and his foot brought to the ground at 30 inches distance, measured by the pace-stick, from heel to heel. This is the slow step: in stepping out the pace is lengthened to 33 inches. In the ranks, not only is length of stride and consequent speed of movement gained by this proceeding, but it enables an uniform pace to be preserved with bodies of troops. At the same time, the length of the marching stride and the movement from the hips unavoidably induce an upward and downward movement of the parts of the soldier's body above the hips. The trunk sinks as the foot is advanced; it is raised as the limb is again brought vertically under it. This alternate elevation and depression is sufficiently manifest to anyone who observes a line of troops advancing towards him, or, more conspicuously still, if they are moving on the other side of a hedge, with only the upper parts of their body exposed. The kind and length of pace just described will not answer so far as stretchers are concerned, if they are to be carried to the best advantage. The gait of the hawker who habitually carries a basket of crockery, or

of a man carrying a bucket of water, on his head, is the most suited to the circumstances of a patient carried on a stretcher; for, with such a gait, the trunks and arms of the bearers, and, consequently, that which they are carrying, are least lifted up or moved. The peculiarity of this gait is, that in it the hip-joints are used as little as possible, the advance is made with the knees kept bent, and the step is shorter. The knees are never wholly straightened, as in marching. The length of the pace is about 20 inches.

The difference in the rise and fall of the upper part of the body between a pace of 30 inches, and one of 20 inches, is greater than might be suspected. When two men holding a stretcher without a man upon it make together a pace of 30 inches, measured from heel to heel, the dip of the stretcher is $3\frac{1}{2}$ inches; with a man upon it, the arms being then stretched to their full extent by the weight, the dip is $4\frac{1}{4}$ inches. When the pace is 20 inches, the dip, without a man upon the stretcher, is only $1\frac{1}{2}$ inches; with a man, $2\frac{1}{4}$, or about one-half of the dip in the longer pace. Of course, in marching at either pace there is an alternate rise and fall to the same extent, and the effect of this on the elastic poles of a stretcher can readily be imagined. The extent of elevation and depression which has just been mentioned is irrespective of jerking or any other movement, having been carefully measured when the bearers were standing still at each position.

There is another difficulty in applying the ordinary marching step to men engaged in carrying stretchers. The position of the traverse in most stretchers causes it, with a pace of 30 inches, to press severely, especially an iron traverse, against the front and upper part of the advanced thigh of the rear, or No. 2, bearer. The traverse also touches the back of the rear thigh of the front, or No. 1, bearer; but, as the motion of this limb is away from the stretcher, it does not cause any marked inconvenience. The result is, that in trying to march with a pace of 30 inches, the rear bearer is subjected to a sharp blow from the traverse on one or other of his thighs, at every step. A jolt is also, at each contact, communicated to the stretcher and patient upon it. With a pace of 20 inches, the traverse being placed as it now is in the regulation stretcher of the British Service, at a distance of 13 inches, and the edge of the canvas at 11 inches, from the ends of the handles, the thigh of the rear bearer is well cleared from contact with either, and no impediment in this respect is given to the forward motion.

Rule 3. Great care must be taken that the steps of the front and rear bearers are invariably *even and alike in distance*. If the steps do not well and accurately agree in length, there will constantly be a hasty 'catching up' of one or other of the bearers; and the stretcher and patient will be jolted on every occasion when

an effort is thus made to re-adjust the distance. If the bearers march with an exactly corresponding step as regards length, this source of disturbance will be avoided.

RULE 4. When distributing bearers, as far as circumstances permit, men nearly of the same height and strength should be selected for acting together. When a stretcher is supported by men of equal height and proportion, if the ground be level, the stretcher will necessarily assume a horizontal position also, and men possessed of like degrees of strength will carry the weight and move together more evenly. If the ground be uneven, the bearers will have mutually to adapt the height of their respective ends of the conveyance to the irregularities, in order to preserve its level condition.

RULE 5. When slings or shoulder-straps are used to assist the bearers in carrying stretchers, care should be taken at starting that they are so buckled that the parts supporting the poles are all at equal distances from the *surface of the ground.*

RULE 6. As most ground over which wounded have to be carried is likely to present irregularities of surface, it becomes an important matter for bearers to practise the carriage of stretchers, so as to acquire a facility of keeping the stretcher level, notwithstanding the ground is uneven. Bearers trained and habituated to this duty perform it with ease and dexterity, irrespective of differences in their own respective heights; while those who have not practised it are not unlikely to cause considerable distress to the person carried, when they have to carry him up and down hill, in consequence of their deficient training. A concerted action of the front and rear bearers is necessary, and each must be aware what part he is to perform, according as the end of the stretcher at which he is placed is rendered higher or lower by the unevenness of the surface over which they are passing. The art can readily be acquired by practising the carriage of the litter up and down steps. In this practice the front and rear bearers should occasionally change their respective positions. A bearer should also be carried on the litter in turn, so as to be made practically aware of the effects of even and uneven carriage.

RULE 7. If the ground over which the conveyance has to pass presents a general ascent, and the bearers are of different heights, then the rear or No. 2 bearer should be the taller and stronger man; for his greater height, and the greater strength of his arm, will be useful in supporting and raising the stretcher up to the level of the end carried by the foremost man. The weight of the stretcher will naturally be thrown in the direction of the man on the lower level.

RULE 8. If the ground presents a general descent, the front or No. 1 bearer should be the taller and stronger, for the same reasons as those just given in regard to the No. 2 bearer, under the opposite circumstances mentioned in Rule 7.

Rule 9. A sick or wounded person on a stretcher should be carried, if the ground be tolerably level, with his face looking towards the direction in which the bearers walk. The front, or No. 1, bearer then supports the end of the stretcher at which the patient's feet are placed; the bearer near the patient's head is the rear bearer.

Rule 10. If the bearers have to carry the stretcher up hill, the front bearer should support the end of the stretcher on which the patient's head is placed, excepting in the case mentioned under Rule 11.

Rule 11. If the bearers have to carry the stretcher down hill, the rear, or No. 2 bearer should support the end on which the patient's head is placed. The reverse position should be assumed by the bearers, both as regards going up hill and going down hill, in case the patient being carried is suffering from a fracture of the thigh or leg.

In the exception named, a reverse position of the patient is given to prevent the weight of his body pushing the upper end of the broken bone down upon the helpless and motionless portion of the limb below the seat of fracture.

Rule 12. A wounded patient should not be carried over a high fence or wall, if it can possibly be avoided; it is always a dangerous proceeding. The danger is of course increased in proportion to the height of the wall or fence; but even if the wall be not much higher than one over which the bearers can step, the stretcher must be made to rest upon it to the inconvenience and probable pain of the patient, while each bearer in succession gets over the obstruction; and it is better to avoid even this inconvenience, provided the avoidance does not entail great delay. If the fence or wall be high, either a portion of the wall should be thrown down, or a breach made in the fence, so that the patient may be carried through on the stretcher; or, if this be not readily practicable, the patient should be carried to a place where a gate or opening does already exist, notwithstanding the distance to be traversed may be increased by the proceeding. It is better that the transportation should be somewhat delayed, than the safety of the patient's limbs or life risked.

Rule 13. In crossing a ditch, dyke, or hollow, the stretcher should be first laid on the ground near its edge. The first bearer then descends. The stretcher, with the patient upon it, is afterwards advanced, the first bearer in the ditch supporting the front of the stretcher while its other end rests on the edge of the ground above. While it is thus supported, the second bearer descends. The two bearers now lift the stretcher to the opposite side, and the forepart being now made to rest on the edge of the ground, while the rear part is supported by the second bearer in the ditch, the first bearer is left free to climb up. The stretcher is now pushed or lifted forward on the ground above, and rests there, while

the second bearer climbs up. The two bearers then carry the stretcher on.

Rule 14. On no account should a stretcher be permitted to be carried on the shoulders of two or four bearers. The evil of such a proceeding is not only that it is difficult to find several bearers of precisely the same height, so that a level position may be secured, but also that the wounded or sick person, if he should happen to fall from such a height, owing to the helpless condition in which such a patient usually is, is not unlikely to sustain a serious aggravation of the injuries he may already be suffering from. General Stonewall Jackson, of the Confederate States' Army, is said to have apparertly owed his death to neglect of this rule. He was being removed, wounded, from the field of action, on a stretcher, by four bearers. The stretcher was carried on their shoulders. One of the bearers, while engaged in this duty, was shot, and fell, and the General was immediately thrown off the stretcher. The suddenness of the event, and the height from which he fell, caused General Jackson to come into contact with the ground with such force that not only the character of his wound, which was by no means a mortal one, was aggravated by the blow, but he received also a severe concussion of the chest, which was followed by inflammation, and appeared to be the immediate cause of the fatal termination which ensued. Moreover, one of the bearers of a stretcher ought always to have his patient in view, so as to be aware of hæmorrhage, fainting, or other change requiring attention, taking place; and this cannot be done when the patient is carried on the shoulders. The height, too, is calculated to cause the patient uneasiness and fear of falling off, which it is also desirable to avoid. For all these reasons, notwithstanding that bearers will often attempt to carry a patient on a stretcher upon their shoulders, from the weight being borne more easily in that position, or with a view of relieving a fatigued condition of the arms, the practice should be strictly forbidden.

Rule 15. If the wounded man lying upon a stretcher have to be transferred into an ambulance wagon, a third bearer should always be employed to assist in the proceeding. This is provided for if three bearers accompany the stretcher, as contemplated in the foregoing instructions. On the arrival of the stretcher at the wagon, the bearer near the part which is first to be inserted should be ready to move round the end of the pole in his left hand, retaining, while he does so, the support of this pole only. Before he makes this move, however, the No. 3 bearer must grasp the right-hand pole; the hold of it should on no account be given up by the first bearer until he has quite ascertained that the pole is fully supported by the No. 3 bearer. When this is known to be accomplished, the first bearer turns round, supporting the left pole at the side as he does so, and then, acting in concert with No. 3

bearer, these two bearers together raise the ends of the poles, which are now free, into the compartment of the wagon which is destined to receive them. The bearer at the head of the stretcher at the same time takes care to maintain it level, and assists in effecting its entrance into the wagon by pushing it forward. By adopting this method the admission of the stretcher is effected with ease, rapidity, and perfect security, while two bearers can only accomplish the object with difficulty, and not without risk of accident to the patient.

Although the instructions and rules above given occupy rather a considerable space in description, they have been found to be acquired and practised without difficulty by men who have been properly instructed in them. The men, after having been trained, carry them out naturally, as it were, and perform their duties as bearers of sick and wounded with more speed and satisfaction than they could possibly be done without a fixed system of proceeding, and the intelligent action which results from it.

(B.) *Wheeled Stretchers.*

General remarks on wheeled stretchers.—Wheeled stretchers are articles of ambulance transport of modern invention. They were employed for the first time as auxiliary means of transport in the German War against Denmark in 1864; and the experience then gained led to very warm expressions regarding their utility by some army surgeons. They have only recently become part of the regular ambulance equipment of the British army.

Wheeled stretchers have been designed with a view to supply means of making up for the deficiency of bearers which has always been experienced when wounded men in large numbers have had to be carried by hand-stretchers, as well as to diminish the labour entailed upon the bearers who are engaged in their removal. Under particular circumstances, when the nature of the ground is favourable for their employment, they offer other important advantages; especially that of effecting the removal of the wounded more rapidly than it can be accomplished when they are carried on hand-stretchers—thus saving them from prolonged exposure, and affording them an opportunity of more early surgical assistance.

The experience of the war between Germany and France in 1870–71 did not tend to confirm the good opinions which had been previously held regarding wheeled stretchers as conveyances for wounded men near the scene of conflict. A certain number of them were taken into the field with the German sanitary detachments, but it was found that they could very rarely be used with advantage between the fighting lines and the field-hospitals. In consequence of this experience, it has been determined in the German army to discontinue the use of wheeled litters in the equipment of the

sanitäts detachements, and to retain them for use only with intermediate and stationary hospitals, and in garrisons. These appear to be the more practicable spheres for their employment in time of war; at the same time, they can always be made use of wherever level roads exist, when ambulance wagons are not available, and it is a matter of importance to save the time and labour which would otherwise have to be expended in the carriage of sick or wounded men by hand.

A wheeled stretcher consists of two distinct parts: the stretcher, and the wheeled support. In respect to the stretcher, the adaptation of the same one which is used for hand-conveyance to the

FIG. [illegible].

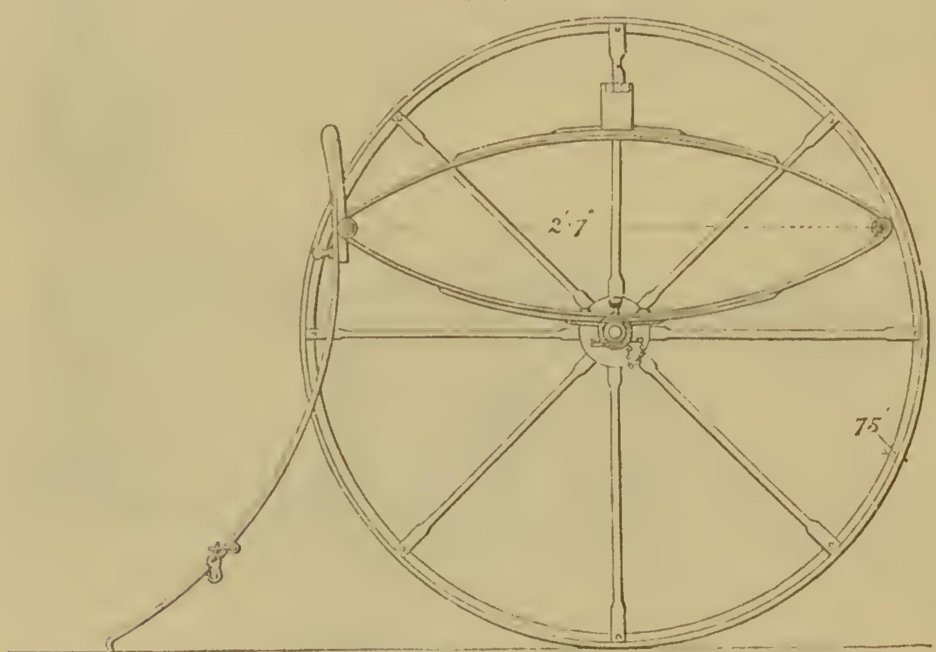
Wheeled Stretcher Complete.

wheeled support presents so many obvious advantages, that it has been adopted as a principle in the construction of the wheeled stretcher of the British service. There are other points of importance to be attended to in the construction of a contrivance of this kind. It must be made capable of being easily taken to pieces for stowage, and of being easily put together again when required for use. It must be strong enough to stand rough usage, but must be light enough to be lifted by two men over a ditch, bank, or low wall in case of need. The mode of connection between the stretcher and the wheeled support must be simple, so that the stretcher with a patient lying on it may be placed on the support

or taken off it with ease and celerity. The position of the stretcher on the support must be so arranged, and the weight adjusted, that the whole may be readily either drawn, or pushed, by a single bearer, at the same time that the wounded man upon it has as much security and ease as practicable. These principles have all been kept in view in the construction of the British service pattern.

Wheeled stretcher of the British army.—The 'stretcher' is the same as that already described. The 'wheeled support' is composed of steel and iron throughout, and is therefore not liable to deterioration from long storage. It consists of an axletree, a pair of wheels, a pair of elliptical steel springs, with crutches on their upper surfaces to receive the stretcher poles, and a pair of folding legs. The axletree is made of $\frac{3}{4}$ inch square steel, with a metal

Fig. 50.



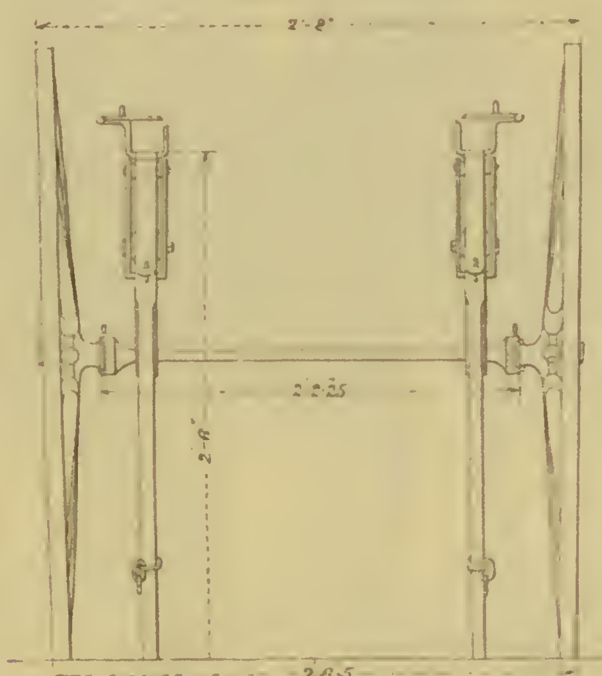
Sectional side view of Wheeled Stretcher Support, with measurements.

cap at each shoulder. The wheels are 3 feet in diameter. Each consists of eight steel spokes, deeply hollowed on opposite sides, screwed into a wrought-iron nave, and riveted to a T-iron tire, 1 inch in width. The nave is made to secure the wheel on the axletree arm. The springs are made from $1\frac{1}{4}$ by $\frac{1}{4}$ inch spring-steel, and are each two leaves in thickness. On the top of each spring is a galvanised iron crutch to receive the stretcher pole, with a hinged flap and turn-stud to secure it when in motion. When the wheeled stretcher is required to be stationary, the hinged flap, just mentioned, is folded back, and it then forms a stop for the wheels by including one of the spokes in a notch on its end. At the bottom of each spring is a clip, with a stud, split key and chain, to secure it to the axletree. The legs are attached to the rear of

the springs by a double joint, and are curved so as to fold over the springs when packed. They assist in keeping the stretcher in a horizontal position when the support is stationary. When not required for use, they are lifted up, and each secured to the corresponding side pole by a shackle and hook. The height of a stretcher when placed on the support is 2 feet 7½ inches.

The weight of the wheeled support without the stretcher is 74 lbs. 13 oz.; with the stretcher upon it, 100 lbs. 5 oz. The whole is made to take to pieces and to pack up in a small space for stowage. A canvas cover or case is provided for it. As bearers must be trained in order to carry patients on hand-stretchers properly, so they have to be instructed in quickly unpacking and

FIG. 51.



Front view of Wheeled Stretcher Support, with measurements.

putting together the stretcher support, and in using it in connection with the stretcher when a wounded man is to be conveyed by it, or to be transferred from it to an ambulance wagon.

(C.) *Mule Litters and Cacolets.*

General remarks on mule litters and cacolets.—These are conveyances borne by mules, and only designed for use in mountainous countries, where there are no roads practicable for wheeled conveyances, and where the distances are too great for transport by hand-stretchers. They do not form part of the ambulance transport under ordinary circumstances of campaigning. The litters are

for patients requiring a recumbent position: the cacolets for patients who are able to be carried in a sitting posture.

Mule cacolets and litters were first introduced into ambulance equipment in the French army in Algeria. Had it not been for these contrivances the French wounded in many of the expeditions in the mountainous parts of that country could not have been transported from the scene of action to a hospital; and no less an authority than Marshal Bugeaud was led to say, that Algeria could

Fig. 52.

Mule Cacolets.

hardly have been conquered without them, such would have been the dispiriting influence on the troops if they could not have felt secure of being saved from the Arabs in case they should be wounded. Finding these means of conveyance of such value in Algeria, the French subsequently adopted them as the principal forms of their ambulance transport for general service. When not required to carry sick or wounded patients, they can be folded up flat against the sides of

the mules, and other packages, such as boxes of biscuits, can be slung and carried over them. Mule litters and cacolets were introduced among the articles of English ambulance equipment during the Crimean War. They were found to be very useful in the Crimea for carrying the wounded along the narrow ravines leading up from Sebastopol; and also for conveying them from the camps to the ports of embarkation, before roads suitable for wheeled vehicles existed.

Only strong and large-framed mules are suitable for the carriage of wounded men on litters and cacolets. The animals also require

FIG. 53.

Mule Litter

a certain amount of training, as well as their conductors. The motion communicated to the litters when the mules are walking is peculiar. It is quite different from the jolts or concussions that a patient is liable to meet with in a wheeled vehicle; it is a sort of pitching motion, and, with some persons, creates a feeling akin to sea-sickness. Two mules carrying wounded can be coupled by means of a chain, one in front of the other, and conducted by a single soldier holding the bridle of the first mule.

Mule cacolets authorised for use in the British army.—These contrivances consist of wrought iron folding chairs, arranged for

being hooked by pairs to the two sides of a packsaddle upon a mule. Each cacolet can be placed either on the right or left side of the packsaddle; and each forms a seat for one patient. A foot-board is attached to each cacolet. A broad strap crossing the patient in front assists in keeping him steady in his seat. The weight of a pair of cacolets is 56 lbs.; the weight of the regulation packsaddle is $30\frac{1}{2}$ lbs. The drawing (fig. 52) will furnish a better idea of this mode of conveyance than a more lengthened description.

Mule litters authorised for use in the British army.—These conveyances are also made of wrought iron. The framework of the litter is jointed into three principal divisions, so that the whole may be folded up in a compact form when not in use. Each litter when extended is about $6\frac{1}{2}$ feet in length. The bed of the litter is made of strong canvas secured to the frame by cords. There is a canvas hood which can be raised at pleasure for purposes of shelter against rain or solar heat, while another piece of canvas attached to the foot of the frame can be drawn upwards so as completely to cover a patient. The hood and cover are omitted in the drawing (fig. 53) in order to convey a better idea of the position of a patient lying on one of these conveyances. The weight of a pair of litters complete is 94 lbs.[21]

(D.) *Sick-Transport Wagons.*

General remarks on sick-transport wagons.—Ambulance sick-transport wagons are four-wheeled vehicles specially constructed for the transport of sick and wounded soldiers. They are not adapted for commissariat or other store purposes. In some armies vehicles have been constructed to serve the double purpose of carrying either stores or patients; and if the same conveyances could be made equally suitable for bearing great weights, and for the carriage of wounded men, in regard to the adjustment of springs, the required internal fittings, and the necessary means of protection for patients, it would manifestly be a desirable arrangement on the score of economy. But all attempts to secure such a result have failed. Moreover, experience has proved that when sick-transport conveyances are permitted to be used for any other purposes in military service than those for which they have been specially designed, practically they will seldom be forthcoming when they are required for the carriage of the sick and wounded.

The relative advantages of two-wheeled vehicles and four-wheeled vehicles for ambulance purposes have been much discussed. On the whole, the greater stability of the wagon as compared with that of the cart, its security notwithstanding an accident happening to one of the horses, and its freedom from the movement which is a result of the mode of connection between the shafts and body in a two-wheeled vehicle, have been thought suffi-

cient grounds for a decision in favour of wagons for sick-transport purposes in the British service.

Ambulance wagon of the British army.—The ambulance sick-transport wagon of the new pattern has been designed for draught by two horses. At the same time appliances are provided for attaching two others in case that animals of sufficient strength cannot be obtained, or on other occasions of need. The wagon is

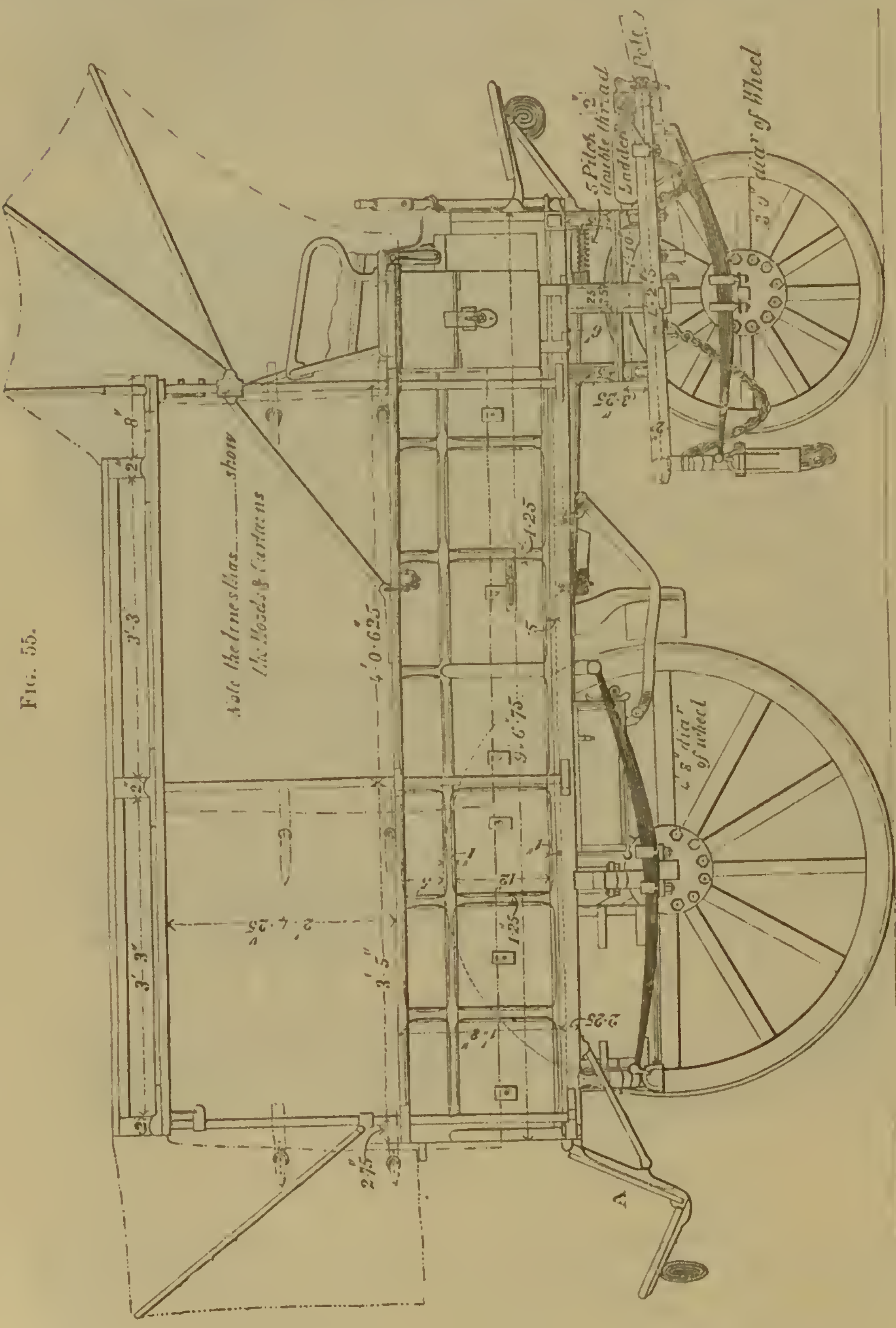
FIG. 34.

Perspective view of the New Pattern Ambulance Wagon.

arranged for accommodating two slightly wounded men, together with the driver, sitting in front: two badly wounded lying on stretchers in the body of the wagon: and three slightly wounded, or two with an attendant, seated behind, and resting their feet on the ledge of the tail-board. It can be either driven from the box, or the driver can ride and drive, as is done in most other military vehicles; all the appointments are provided for either mode of

conducting the wagon. The diameter of the fore-wheels is 3 feet; of the hind wheels 4 feet 8 inches. The reduced diameter of the

FIG. 55.

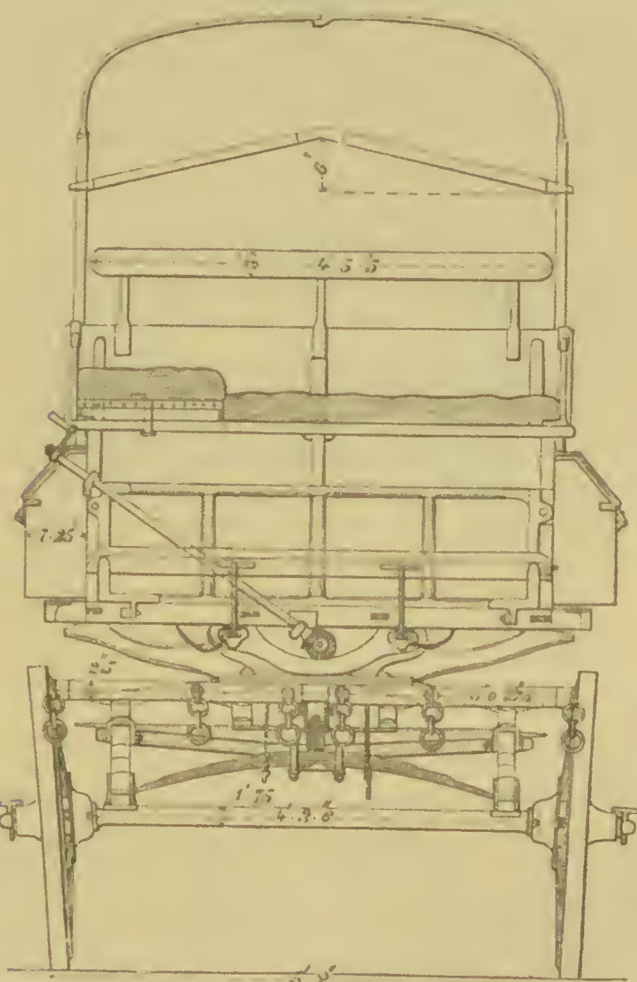


Side Elevation of New Pattern Ambulance Wagon, with measurements.

fore wheels is to enable the wagon to turn on its own ground. This could not be done with the wagon of the previous pattern, as the front and hind wheels were of equal diameters. The increased

draught, owing to the reduction of size of the fore wheels, is to a great extent counterbalanced by less weight being thrown on them than on the hind wheels. The springs are semi-elliptical, carefully adjusted to the weight to be carried: a cross check spring being added behind to come into play when the full complement of men are placed in the wagon. A break, acting on the hind wheels, is worked by the driver from his seat in front; and a drag-shoe is

FIG. 56.



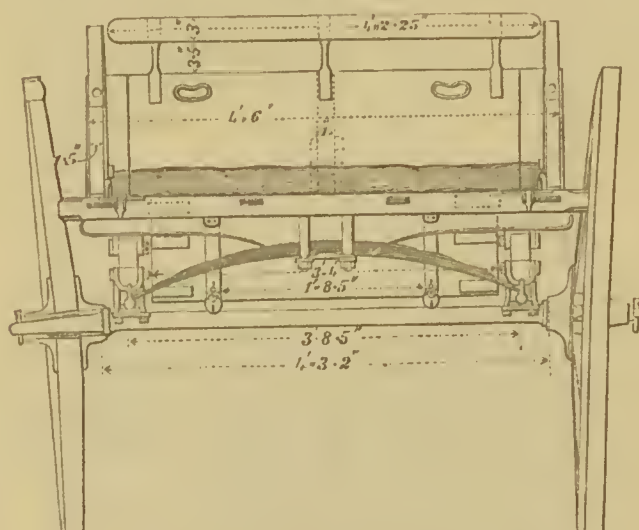
Front Elevation of New Pattern Ambulance Wagon, with measurements.

suspended from the near futchell of the fore-carriage. A zinc water-tank, cased in wood, and fitted beneath the floor of the wagon, is made capable of containing ten gallons of water.

Behind the water tank is a locker for forage and utensils; it is accessible through the floor of the wagon by two padlocked trap-doors. The available floor space inside the wagon is 9 feet $5\frac{1}{4}$ inches, by 4 feet 3 inches. The height of the sides of the wagon is 1 foot 8 inches; they are boarded for the first 14 inches, and open

from the middle to the upper rave, about 5 inches. The portion of the floor for the recumbent patients is divided longitudinally by an upright board 14 inches high. Special fittings were provided to facilitate the insertion of a stretcher on each side of this partition, but these, as will be explained presently, are now undergoing alteration. The roof of the wagon is framed, and hinged in the centre to facilitate package. It is supported on tubular iron standards. Straps are attached to these standards for carrying two spare stretchers on each side, on the top of the side rail of the wagon. These stretchers are carried rolled up: the pillows belonging to them are secured by straps to the ridge-pole of the roof. The framed roof is filled in with double canvas, the two layers being fastened together by indiarubber solution. It is thus rendered impervious

FIG. 57.



Rear Elevation of New Pattern Ambulance Wagon, with measurements.

to rain. The sides are single canvas, arranged to be fixed down, or rolled up to any required height at pleasure. Places are provided for the valises of the wounded men between the stretcher-handles, before and behind. There are also straps fixed to the floor of the wagon for securing the rifles of the wounded men. It will be very necessary, before depositing these weapons, always to ascertain that they are not loaded. The weight of the wagon and fittings is 18 cwt.; the calculated weight when loaded with eight persons and their kits, a little over 30 cwt. This is a manageable weight for draught by two horses; regard being had to the fact that, as a rule, the wagon will only be required to move over made roads, and not faster than at a walking pace.

A special difficulty, which has been before referred to, exists in respect to every vehicle belonging to the British army, and influences

all the details of their construction. Owing to the insular nature of Great Britain, the whole of the army equipment, including the wagons, to be available for military operations in a foreign country, must be capable of being carried by sea. An ambulance wagon has, therefore, itself to be made portable. In the present instance the whole wagon is made so as to be readily taken to pieces, folded up, and to be put together into a convenient package, for stowage on board ship.

A practical illustration will show the importance of this arrangement. During the late Franco-German war the 'British National Society for aid to wounded in time of war' obtained from the War Office twenty ambulance wagons, for use with the ambulance sent to France under the direction of Deputy Inspector-General, Dr. Guy. Eight of these ambulance wagons were for the transport of wounded, and twelve were general service wagons adapted for the transport of stores. All these vehicles were made up into packages, and placed on board ship at Woolwich. They were accompanied by some non-commissioned officers and twenty privates of the Army Hospital Corps, who had been trained in their use and particular construction. On arrival at Hâvre, the packages were got out of the hold of the vessel and placed on the wharf. They were then unpacked and the different parts put together. The whole operation was completed with regularity and dispatch, and the twenty wagons, complete in all respects, were ready to proceed on the road under five hours from its commencement. Had the attempt been made to convey the vehicles over the comparatively short distance between the Thames and the French coast in their ordinary condition, not only would the vessel which conveyed them have been insufficient in size for their accommodation, but those which it could have carried would scarcely have escaped from being damaged during the voyage. Objections have been made to the solid, and, therefore, proportionally heavy construction of British ambulance wagons. But the advantages of their solid construction were also exhibited in the instance of the wagons just noticed. They were subjected to very severe usage during the whole of several months in the trying winter of 1870-71; yet, in the following spring, they returned to England in so serviceable a condition that the Government readily consented to repurchase them from the Society to which they had been sold.[22]

There was one feature in the new pattern ambulance wagon which was open to objection, viz. the plan for inserting and removing the patients lying on the stretchers. This was effected by a system of guide-bars, placed along the sides of the wagon and the centre partition, upon which slide-rests, fitted with crutches for the reception of the poles of the stretchers, were made to travel. The lower part of each stretcher was thus kept clear of the floor of the wagon. This arrangement was easily applied

by men who had been well trained to it; but it was too complicated, and too easily deranged, for use by persons who had not had the necessary practice. As it was not unlikely to happen that persons who were not practically acquainted with the purposes of the different parts of the contrivance would sometimes have to be employed in placing recumbent patients in the wagon and taking them out of it, it was felt to be very desirable that this system should be simplified. This is now being accomplished. The special fittings for facilitating the insertion of the stretchers and supporting them, above described, are being removed, and the floor space left vacant. It has been before mentioned that rollers are being fitted to the feet of the regulation stretchers, so that they may be pushed along the floor of an ambulance wagon on their own rollers. Wedges, secured by lanyards within the wagon, will keep the stretchers in position after they have been inserted.

(E.) *Railway Hospital Trains.*

General remarks on railway hospital trains.—The transport of sick and wounded by railways has been immensely developed during recent wars. This mode of transport was largely used during the United States' great Civil War, and the Bohemian war of 1866; but was more than ever employed during the late war between France and Germany. The removal of wounded by railway has been effected both by ordinary goods' trucks and wagons, and by passenger carriages, temporarily adapted to the purpose; and also by railway carriages, and, in some few instances, by complete hospital trains, specially built and furnished for removing sick and wounded troops. Carriages and trains of the latter description, of various patterns, formed conspicuous objects in the sanitary department of the Vienna World Exhibition of 1873, as well as in the Sanitary Exhibition at Brussels in 1876. Railway hospital trains do not form a portion of field-hospital transport equipment, properly so-called. They are, however, closely connected with it, as they are frequently employed for evacuating the field-hospitals of their wounded, and carrying them either to intermediate, or to permanent hospitals, at a distance in rear.

If ever an invasion of any part of Great Britain should be attempted, and a conflict ensue on her shores, the amount of suffering, and the safety of the lives of many of the wounded, will be materially influenced by the nature of the provision which will have been made in respect to the manner of their conveyance by the railways to the hospitals in the interior. It is by the railways that the great proportion of the wounded will have to be removed. Improvised railway conveyance of badly wounded men has hitherto been always attended with aggravation of their injuries and increased suffering, and has often materially augmented the gravity

of their general condition. Great attention has been given to the subject of railway ambulance transport by continental nations, who have had practical experience of its importance, but no official settlement regarding it has been promulgated in our own country. A railway ambulance sick-transport carriage, in the design of which I was personally concerned, has been specially constructed, and has been employed for some years past in the conveyance of military invalids between Portsmouth and Netley. It is fitted with berths, heating and cooking stove, and all necessary appliances for the requirements of the patients during the journey; but this carriage would form no guide to the provision which would have to be made on the occurrence of war. It would be impossible to construct such carriages in sufficient numbers, or, if constructed, to ensure their presence at the particular points where they would be required in case of a landing on our shores being attempted, and a battle ensuing. The problem which requires to be solved is how best to convert the existing railway conveyances which may be found at any station, especially those which are likely to be used for carrying baggage and stores to the front of an army, into efficient and suitable carriages for the removal of wounded men. Such carriages should comprise ready accessibility of the patients to surgeons and attendants, proper available supports and positions for them, together with freedom from injurious movement and disturbance; while, at the same time, due regard should be had to economy in cost, mechanical simplicity, sufficiency of strength, speed of conversion, and to the necessity for such a system of altering the existing vehicles as will not prevent them from reverting to their former uses when they are no longer required for hospital purposes. This problem is really only second in importance to that which has received attention from the military authorities for a long time past, viz., the means of conveying men and materials by railway, to any given point, in sufficient force for the purpose of resisting an attempted invasion.

The mode of conversion of railway luggage wagons, which has appeared to me to comply most closely with the requirements just named, is one which has been designed and described by Major-General Zavodovsky, of St. Petersburg. The Zavodovsky system was adopted by a Commission appointed by the Russian Minister of War in 1873 to inquire into the question of the transport of wounded by railway in time of war; and, I am informed, has also been selected as one of the means of railway transport for the Austrian army. It was exhibited in the Russian Department of the Sanitary Exhibition at Brussels in 1876. I have personally assisted in a series of trials of it under various circumstances. At one time a luggage van, to which the appliances had been fitted, was subjected to violent jolts and sudden halts; at another time, was attached to a fast train on the South Eastern Railway, and I found

myself, while lying on one of the stretchers, on each occasion subjected to far less disturbance than I had previously supposed this, or any other mode of elastic suspension of stretchers, would have permitted. The articles inserted in the wagon for carrying the stretchers on this system are so cheap and simple, and so easily stored, that a sufficient quantity might be kept in reserve to meet a sudden exigency without inconvenience or much expenditure.

The following description and drawing are taken from a pamphlet by General Zavodovsky, and will serve to explain the nature of the means by which the stretchers are suspended. Ordinary field stretchers are employed.

Each set of the appliances will support 4 stretchers in 2 tiers. A single wagon may therefore be adapted to carry either 4 or 8 patients, according to its length. To receive the 4 stretchers, 2 cables (A A) an inch in thickness are suspended across the top of the van and secured at each end by iron rings and hooks which are fastened to the wall of the van, $2\frac{1}{2}$ inches below the roof. To each of the 2 cables is attached, horizontally, at three points (*b b b*) a pole of any strong springy wood, such as oak, ash, or birch, adapted to the width of the van, but at least 8 ft. long. Each pole should be $2\frac{1}{2}$ in. thick in the middle and $1\frac{3}{4}$ in. at the ends. Four cords (*c c c c*) are now attached to each side of the 2 horizontal poles, with knots (*x x x x*) so arranged that they may support the stretchers (D D D D) on a level.

To prevent the stretchers, when the patients are upon them and the train is in motion, from swaying to and fro, or striking against the sides of the van, the supports of the lower tier of stretchers are fastened by cords to three small iron hooks (*z z z*) screwed into the floor of the van.

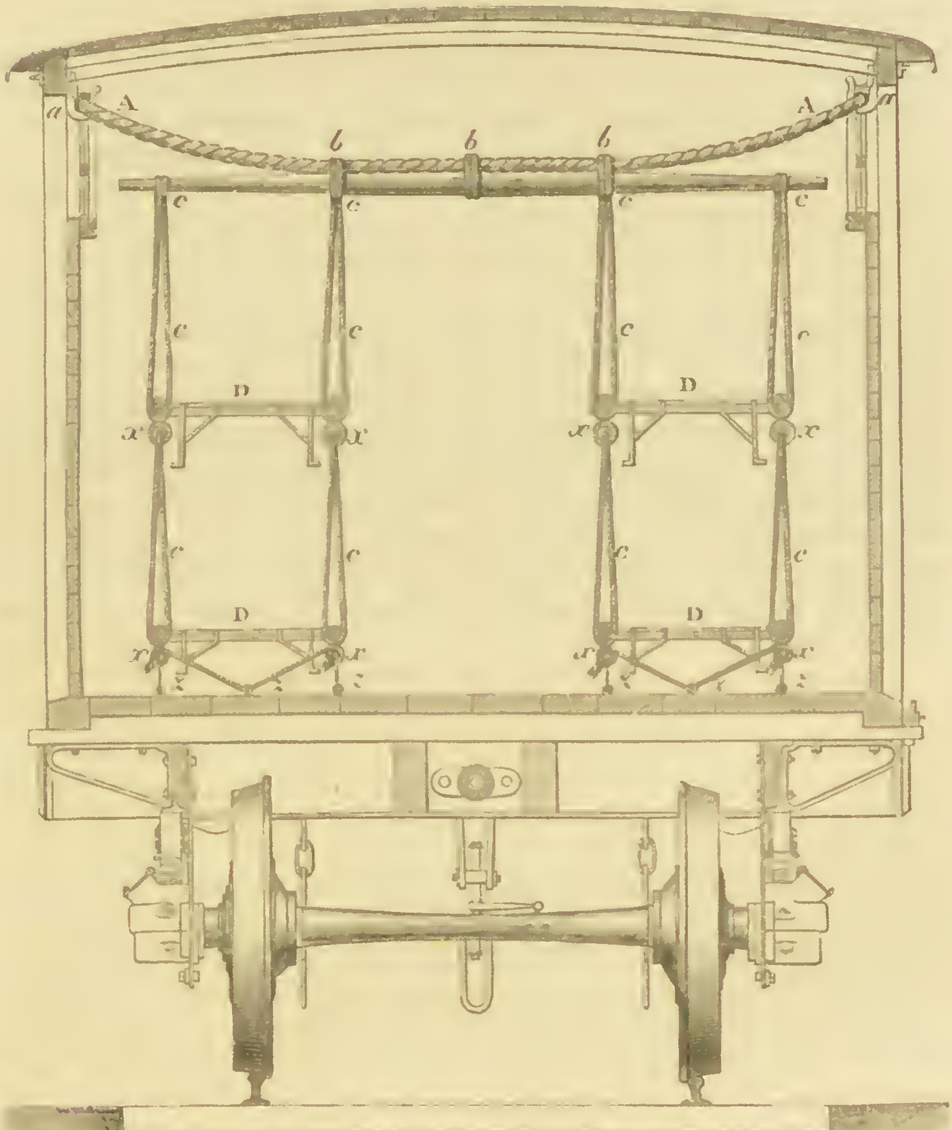
In the absence of iron hooks and rings, the top cross cables may be passed through holes bored in the sides of the van, and then secured by knots.

When patients are to be inserted, two men lift each of the stretchers in succession, with the patient upon it, through the side door of the van, and, turning round, at once put them in their places. The first stretcher is put in the upper, the next in the lower loops, of the vertical suspending ropes. Each tier of stretchers is then secured to the hooks in the floor of the van. When the patients are to be removed from the van, the ropes that secure one of the sets of stretchers to the floor are first loosened. The patient on the lowest tier is first carried out, and, afterwards, the one above him.

The attention which has been given to the practical working of railway ambulance transport, and the experience which has been, and is still being, gained regarding it on the Continent, is well worthy of being turned to a profitable account by British surgeons. The construction, organisation, and administration of

Railway Hospital Trains, have been systematised in Germany for a long time past. In Austria a Sanitary School Train has been established at Vienna by the Sovereign Order of Maltese Knights, between whom and the Ministry for War an arrangement has been made for the Order taking charge, in case of war, of 12 Sanitary

FIG. 78.



Section of Railway Wagon fitted with Stretchers on Zavodovsky's System.

Railway trains capable of carrying 160 sick or wounded by each train. These Sanitary trains will consist of covered goods' wagons, temporarily converted into ambulance carriages. To prepare for this undertaking the Order has built at its own expense a sanitary train of 10 ambulance and 4 other wagons, with a view to the prac-

tical instruction, in time of peace, of the officers and attendants who will have charge of the trains in time of war. The technical details for the conversion of the goods' wagons into sanitary wagons have been carried out by the manager of the Railway Carriage Manufactory at Simmering, near Vienna, acting upon the general recommendations of Baron Dr. Mundy, who is the chief surgeon of the Order. All the arrangements are subject to the sanction and approval of the Ministry for War.[23]

It is obvious that, in case of England having to take part in continental warfare, her army must depend upon the railway transport of the country in which the military operations are carried on, should the plan of evacuating any of the field-hospitals by railway be adopted in it. Railway vehicles cannot be sent from England with an army as other wheeled conveyances may be. The sick and wounded may be sent from the theatre of warfare in ordinary vehicles to the country of an ally, and thence be dispatched by railway hospital trains to a coast; or they may be sent by carriages on railways which have been seized in the hostile country itself. In any case, England must depend, so far as railway hospital conveyance is concerned, on the railways and the carriages found in the countries in which the English troops are operating. It is advantageous, therefore, to be acquainted with the nature of the railway ambulance transport, and the system on which it is arranged to be conducted, in different European countries; but it would be foreign to the purpose of this work to pursue the subject further in its pages.

SECTION X.

ON THE NOSOLOGICAL CLASSIFICATION OF GUNSHOT INJURIES IN GENERAL AND IN ARMY STATISTICAL RETURNS.

CHAPTER I.

ON THE GENERAL NOSOLOGICAL CLASSIFICATION OF GUNSHOT INJURIES.

Denomination of gunshot injuries in nosological classification. — The army nosological classification which passed away a few years ago, was identical with that devised by Dr. Farr, Registrar-General of England, for use in the mortality returns of the civil population. It comprehended a special class of '*Lesions from violence tending to sudden death*,' under the name '*Thanatici*.' The second order of this class '*Polemici*,' included all lesions resulting from battle; and, among them, of course, the particular species of lesion which is produced by gunshot, and which, in this nomenclature, was designated 'Vulnus Sclopetarium.' The adjective 'sclopetarium,' was taken from the word 'sclopetum,' a gun: a term first employed about the date of the application of gunpowder to destructive weapons. The celebrated surgeon and anatomist of Padua, Fabritius ab Aquâpendente, writes of leaden bullets discharged from fire-arms as 'globuli plumbei à sclopetis emissi,' and of gunshot wounds as 'vulnera è globulis sclopetorum facta.' Analogous phrases are universally met with in the works of the principal surgeons and authors of the sixteenth and seventeenth centuries. The term 'Sclopetum' was selected as indicative of the sudden noise produced by the discharge of a gun, and was derived from the Roman 'sclopus,' signifying the explosive report produced by a person quickly striking his two cheeks after they have been distended by holding his breath.[1]

The Committee appointed by the Royal College of Physicians of London to draw up the Nomenclature of Diseases, which was published in 1868, did not adopt the same term for a gunshot wound; but, going back to a period before fire-arms were invented, have given the expression 'Vulnus ex tormentorum pilis,' as the Latin equivalent for a gunshot injury. (*See* Nomenclature, p. 196.)

So far as the mere word 'tormentum' is concerned, it certainly has a more classical origin than the word 'sclopetum,' coined from 'sclopus' can claim: but whether it is more correct to apply it to wounds produced by shot from fire-arms, considering the totally different nature of the mechanical appliances comprising the Roman 'tormenta,' or whether it is more appropriate for a general nomenclature than the familiar Latin equivalent, which has been adopted by all the authors of Latin treatises on gunshot wounds since gunpowder was invented, and is still the ordinary expression in foreign countries whenever a Latin term for gunshot wounds is used,[2] seems, at least, to be open to much doubt.

Arrangement of the subdivisions of gunshot injuries in recent nosological classification.—The Nosological Classification Committee, as is well known, also broke up completely the structural system previously in use. That the action of the committee in this respect was a right one, has been generally allowed; involving, as the previous plan did, so many debateable points in reference to the causation and nature of the particular morbid conditions mapped out by it. On looking, however, into the new arrangement, so far as concerns the special subject of 'gunshot injuries,'[3] there are some questionable details which it may be useful to notice.

The Nomenclature Committee based their general classification of diseases upon anatomical considerations, grouping diseases into 'General' and 'Local.' The latter group includes the order 'Injury.' This order is again divided into 'General Injuries' and 'Local Injuries.' The Local Injuries are further separated into eleven subdivisions: viz., 1. Injuries of the head and face (the injuries of these two regions being again separated and marked A and B respectively in the Nomenclature); 2. injuries of the eye; 3. of the neck; 4. of the chest; 5. of the back; 6. of the abdomen; 7. of the pelvis; 8. of the upper extremities; 9. of the lower extremities; 10. of the absorbent system; 11. injuries not classified. Eight of these subdivisions of 'Local Injuries' are therefore regional; one is systemic, viz. that of injuries of the absorbent system; one is devoted to a special organ, the eye; while the remaining one is devoted to injuries not included in the foregoing classes.

This arrangement suggests the following queries:—Cannot a classification of local injuries, on a uniform regional system, be adopted without difficulty and with greater advantage? Would it not be far simpler to place injuries of the 'absorbent system' under the several regional classes, in the same way as injuries of the arterial and venous systems have been? Again, would not injuries of the eye stand as naturally in the class of 'Injuries of the Face,' as those of the organs of taste and smell, which have been made to rank among them; or as injuries of the organ of hearing, which have been placed in the class of wounds of the face, but

which had better, perhaps, have been under those of the head, to which region the ear more particularly belongs?

Another noticeable point in the Nomenclature is the following: Recording surgeons are required to specify in all cases of injury, whether they are accidental, self-inflicted, or caused by battle; but, strangely enough, it is only in certain particular injuries, severally mentioned in the Nomenclature (*see* footnotes on pages 191 to 210 in the Nomenclature), that the surgeon is directed to 'specify when from gunshot.' No reason appears why a surgeon is required to specify the fact when certain injuries are caused by gunshot, but not when other injuries have the same origin. In no instance is a surgeon required to specify whether a *contusion* results from gunshot. The surgeon is directed to specify whether a wound of the perineum is from gunshot, but not so in the case of a fracture of the pelvis, or of a wound of the bladder (Nomenclature, p. 203). Under 'Wounds of the Neck,' there is a special subdivision for 'Gunshot Wounds' (Nomenclature, page 197): there is no similar subdivision in any other of the regions into which wounds are divided. A more simple mode of proceeding would appear to be, to give a general direction to all recording surgeons to state the fact, whenever an injury, whether a wound or contusion, results from gunshot. The Nomenclature is issued subject to future revision; and, although minor matters, these are points which may lead to some confusion in practical application of the classification, and may, therefore, be found worth consideration when the time for revision arrives.

CHAPTER II.

ON THE SPECIAL CLASSIFICATION OF GUNSHOT INJURIES IN ARMY RETURNS.

Classification and tabulation of gunshot injuries in time of war.—The nomenclature and definition of gunshot injuries in the general nosological system which is at present authorised for use in this country has been explained in the previous chapter. A still more important matter, so far as the science and practice of military surgery is concerned, is the special classification adopted for tabulating particular injuries in army returns in time of war. Such a classification ought to accord with the conditions which principally distinguish one set of gunshot injuries from another: the conditions which cause them to differ in the phenomena which they present, in the consequences which usually result from them, and mostly also in the treatment which they require for their repair.

The importance of a precise, and at the same time simple,

arrangement for classifying and tabulating the injuries resulting from war can hardly be overrated. The value of all statistical and professional returns bears an exact relation to the degree in which the importance of a truly scientific distribution of the detailed facts and circumstances included in them has been appreciated, and to the extent in which such a distribution has been carried into execution. It is especially important that this should be recognised in the classified returns with which military surgeons have to deal; and in no department of the military surgeon's practice is this importance more obviously apparent than in the department of wounds, especially gunshot wounds. In war these injuries not unfrequently occur in very large numbers together; the occasions are such that surgeons have no time for entering into detailed reports of particular cases; and yet the nature of each case must be defined within some fixed limits, if the records furnished of the whole collected number of wounds are to be turned to practically useful results in statistical tables, either as regards the surgical consequences of the injuries recorded, their ultimate effects in disabling soldiers for service, or for purposes of comparison between the results of various modes of treatment. If wounds of different characters and different degrees of gravity—some complicated with serious lesions of neighbouring organs, others simple and uncomplicated—are mixed together under one heading; deductions drawn from the tabular returns in which they are included must contain so many sources of error as to be rendered unreliable and valueless for scientific purposes. Yet, almost self-evident as this statement appears to be, it was not until the year 1855, nor until ten months after the battle of the Alma, that there was any authorised classification of gunshot wounds in the army medical regulations of the British service. At the date mentioned, July 1855, a systematic classification, which had been formed by Inspector-General Taylor, C.B., was regularly introduced into the army returns, and it is still the form under which all returns of wounds occurring in the field are ordered to be tabulated. Since this was a very important innovation, and as not even an approach to scientific accuracy in the general numerical returns of the injuries received in battle can be said to have existed up to its introduction, it will be useful to explain to some extent the nature of Mr. Taylor's classification, as well as to indicate its practical value. These will be best understood by taking a brief glance at some of the ill results of the previous absence of an authorised system for collecting the general statistics of gunshot injuries.

Field statistical returns prior to 1855.—Previously to the period of the Crimean War, the medical regulations of the army only required a statement to be furnished of the number of gunshot wounds occurring in particular battles and campaigns, for the information of the army medical authorities. No distinction was directed to be

made between one wound and another in these returns. It was, however, expected that, in the professional reports furnished at stated periods by medical officers, the histories of any injuries of particular interest should be mentioned at full length. It was left to the discretion of the surgeons to select the cases to be thus reported. Valuable information was often supplied by particular surgeons in this way, but from the very nature of the proceeding the information was necessarily of a partial character.

A numerical return of the wounds inflicted in each action, in which they were classified according to their supposed gravity, was furnished by surgeons during the Crimean War. The following order on this subject was issued at the commencement of the war: 'As soon after an action as possible, medical officers in charge of corps will make out and transmit to the Inspector-General of Hospitals, for the information of the General Commanding-in-Chief, Returns of Casualties, made out agreeably to the following form': —

Return of Killed and Wounded in ____ Regt., in the Action of ____

	Killed	Wounded			Total Wounded	Remarks
		Dangerously	Severely	Slightly		
Officers . .						
Non-commissioned Officers and men						

This form of numerical return was used during the Peninsular War, and no change in it had been made during the forty years which succeeded the closing scene of the Duke of Wellington's final success at Waterloo. The return was obviously of little professional value. Whether regarded surgically or statistically, it was scarcely in advance of the method of arrangement into 'Mortal' and 'Non-Mortal' wounds, employed by Hippocrates and Celsus, of each class of which they defined regular lists; and scarcely so advanced as those employed by some of their successors. Towards the close of the Crimean War, this numerical return was expanded and converted into a nominal return. In all actions in which British troops have been since engaged, the 'Casualty Returns' furnished by the surgeons in charge of troops or hospitals to the principal medical officer, for the information of the General Officer Commanding the Forces, have included not only the name and rank of each officer, non-commissioned officer, and private, wounded, but also the nature and regional situation of his wound; together with its presumed degree of gravity, under the designations, slight, severe, dangerous, and mortal.[4] These Casualty Returns have now, therefore, a definite value, for they embody information which may be turned to account, not only at the time they are furnished, but also as a record for subsequent use, on the termination of the war.

It sometimes happened, before an official classification was appointed, that surgeons in charge of military hospitals classified, of their own accord, in their professional reports to the Head of the Army Medical Department, the injuries from battle which fell under their care. The value of such tables would obviously vary with the professional attainments of the surgeons who compiled them, and the arrangement adopted by them. Under the most favourable circumstances, however, in consequence of the partial nature of the information afforded, differences in the plans adopted for framing the tables, and sometimes in the professional views held by different surgeons, the tabular returns from these various sources could very rarely be employed with advantage for purposes of general comparison.

The last year in which any considerable number of soldiers were invalided home to England on account of wounds received in action, prior to the time of the Crimean War, was the year 1848. The wounded men referred to were sent from India, New Zealand, and the Cape of Good Hope. The cases of all those who were admitted into the General Invaliding Hospital, then at Fort Pitt, were exhibited together in a special numerical return, the first column of which was intended to show the particular regions of the body wounded, and the remaining columns the results of the wounds and the various ways in which the patients were finally disposed of. The first line showed wounds of the head and face together, and I need hardly mention what different considerations are involved in wounds of these two regions. Wounds of the thorax followed; thirdly, wounds of the abdomen; and, fourthly, wounds of the back; without any subdivisions to show whether the parietes only, or the cavities and viscera connected with the regions named, were concerned in the injuries. Five lines then followed for the upper extremity, viz., wounds of the shoulder, arm, elbow, forearm, and hand; and five for the lower extremity, viz., wounds of the hip, thigh, knee, leg, and foot. There were no indications of injuries of bones, nerves, or arteries, with which some of them were certainly complicated. To what real practical advantage could such information be converted? The few numerical returns of a corresponding kind, which have been handed down from the Peninsular campaigns, are for the most part equally unsatisfactory in their nature. Inspector-General Taylor made the following remarks in reference to this fact when proposing his own scheme of classification:—'The necessity for some such classification as that now proposed is obvious from referring to the returns furnished during the Peninsular War. These will be found nearly uninteresting and uninstructive, in consequence of the want of distinction amongst wounds of wholly different nature and quality. In wounds of the head, chest, and abdomen, no distinction is made between simple flesh wounds of these regions and injuries to the more important viscera. The re-

turns do not even distinguish between incised and gunshot wounds, which are of such totally different value even in the same parts. All kinds of wounds seem brought together simply as "surgical cases;" and in some of the returns of capital operations it is not clear whether fingers and toes have, or have not, been included under the terms "upper" and "lower" extremities.' Investigation fully confirms these statements of Mr. Taylor. It is important to be aware of the fact that these uncertainties and serious imperfections do exist in the comparatively recent professional returns referred to.

System of classification devised by Inspector-General Taylor.—Inspector-General Taylor's classification was formed with the design of removing the objectionable characters of these older returns. Mr. Taylor began his classification in India, at the time of the Sutlej campaign, but completed it in its present shape in the Crimea, when in medical charge of the 3rd division of the army. Early in 1855, an order was issued for Mr. Taylor's form of descriptive return to be used in all army professional documents, both by the surgeons actually in the field, and by those on duty in the general hospitals in the rear.[5]

It may be safely asserted that this was the first time a general classification of gunshot injuries at all approaching to precision—one, too, combining comprehensiveness and accuracy of detail, with all requisite elements of practical utility—had been employed in the army returns of any country. In the year 1859, when the revised code of regulations for the Army Medical Department was published in accordance with the recommendations of the Royal Commissioners, this classification was embodied in them with some slight modifications; and it still remains the form according to which gunshot and other injuries received in action are required to be enumerated, and described, by the surgeons under whose care they come for observation and treatment. The separate returns from the medical officers in charge of the field-hospitals and detached bodies of troops are combined in one general descriptive return, similarly classified by the chief medical officer of the army.

All the injuries among the non-commissioned officers and men received during the Crimean War, and treated in the field and general hospitals from April 1, 1855, to the end of the war, 7,161 in number, have been defined, and the results of their treatment shown, in the official surgical history of the war, by returns tabulated in accordance with Taylor's classification. The injuries of the commissioned officers have been similarly classified for the whole period of the war. This system of classification had not been introduced into India at the time of the Sepoy Mutiny, so that we have no medical and surgical history of that war as we have of the Crimean War; but the wounds of all the men among the British forces who were invalided home to England from their effects have

been tabulated according to it.[6] It was equally applied to the injuries inflicted in the field during the last war in New Zealand.[7] No tables exist by which the vast number of wounds inflicted during the wars in which Great Britain was engaged prior to the Crimean campaign—in the Peninsula, in Belgium, in India, and elsewhere—can be defined; scarcely anything more than their mere total numbers, and these very imperfect, were ever recorded. Such omissions are not likely to happen again in any future wars in which this country may be concerned.

The 'Descriptive Numerical Return,' the history of which I have described in the foregoing remarks, comprehends fifteen classes of injuries. The first twelve of these contain the classification of gunshot injuries; the remaining three classes include those from cutting and stabbing weapons, and others of a miscellaneous kind. During the Crimean War printed copies of the classified returns were issued in forms convenient for the simple insertion of the necessary numbers; while others were so arranged as to afford space for detailed remarks on particular cases of wounds.

The following was the form for the numerical returns:—

Descriptive Numerical Return of Wounds and Injuries received in Action, admitted into the Hospital of the ______________, between the ______ of ______________, and ________ of ______________, 18___ ______________, the ____ of ________, 18___

Classification and Specification of Wounds and Injuries		Remained on the ___, 18	Since admitted	Died	Discharged to Duty	Transferred: To other Hospitals or Stations	Transferred: Readmitted for other Diseases	Transferred: Readmitted for Capital Operation	Remaining on the ___, 18
1. Gunshot Wounds of the Head.	1. Contusions and simple flesh wounds of scalp — Slight								
	— Severe								
	2. With contusion or fracture of the cranium without depression ...								
	3. Ditto, with depression...								
	4. Penetrating the cranium								
	5. Perforating ditto.........								
2. Gunshot Wounds of the Face.	1. Simple flesh contusions and wounds — Slight								
	— Severe								
	2. Penetrating, perforating, or lacerating the bony structures, without lesion of important organs								

DESCRIPTIVE NUMERICAL RETURN OF WOUNDS, &c.—*Continued.*

Classification and Specification of Wounds and Injuries			Remained on the ___, 18	Since Admitted	Died	Discharged to Duty	Transferred: To other Hospitals or Stations	Transferred: Readmitted for other Diseases	Transferred: Readmitted for Capital Operation	Remaining on the ___, 18
2. GUNSHOT WOUNDS OF THE FACE.	3. Penetrating, perforating, or lacerating the bony structures, with lesion of the	______								
		______								
		______								
		______								
	4. With fracture of the lower jaw									
3. GUNSHOT WOUNDS OF THE NECK.	1. Simple flesh contusions and wounds	Slight								
		Severe								
	2. With injury of the	______								
		______								
		______								
		______								
4. GUNSHOT WOUNDS OF THE CHEST.	1. Simple flesh contusions and wounds	Slight								
		Severe								
	2. With injury of bony or cartilaginous parietes, without lesion of contents									
	3. With lesion of contents by contusion, or with non-penetrating wound									
	4. Penetrating, and ball lodged, or apparently lodged									
	5. Perforating contents .	Superficially								
		Deeply								
5. GUNSHOT WOUNDS OF THE ABDOMEN.	1. Simple flesh contusions and wounds	Slight								
		Severe								
	2. Contusion or non-penetrating wound with lesion of	______								
		______								
		______								
		______								
	3. Penetrating or perforating with lesion of	______								
		______								
		______								
		______								

DESCRIPTIVE NUMERICAL RETURN OF WOUNDS, &c.—*continued.*

Classification and Specification of Wounds and Injuries				Remained on the , 18	Since Admitted	Died	Discharged to Duty	Transferred: To other Hospital or Stations	Transferred: Readmitted for other Diseases	Transferred: Readmitted for Capital Operation	Remaining on the , 18
6. Gunshot Wounds of Back and Spine.	1. Simple flesh contusions and wounds	Slight									
		Severe									
	2. With fracture of vertebra, without lesion of spinal cord										
	3. With lesion of spinal cord										
7. Gunshot Contusions and Wounds of the Perineum and Genital and Urinary Organs not being at the same time Wounds of the Peritoneum		——									
		——									
		——									
		——									
		——									
8. Gunshot Wounds of the Upper Extremities.	1. Simple flesh contusions and wounds	Slight									
		Severe									
	2. With contusion and partial fracture of long bones, including fracture of the clavicle and scapula										
	3. Simple fracture of long bones by contusion from round shot . .										
	4. With compound fracture of . .	Humerus									
		Radius									
		Ulna . .									
		Ulna & Radius									
		All three bones									
	5. Penetrating, perforating or lacerating the several structures of the carpus and metacarpus										
	6. Dividing or lacerating the structures of the fingers or thumbs . .										
9. Gunshot Wounds of the Lower Extremities.	1. Simple flesh contusions and wounds	Slight									
		Severe									
	2. With contusion and partial fracture of long bones										
	3. With simple fracture of long bones by contusion of round shot . .										

DESCRIPTIVE NUMERICAL RETURN OF WOUNDS, &c.—*continued.*

Classification and Specification of Wounds and Injuries	Remained on the , 18	Since Admitted	Died	Discharged to Duty	Transferred: To other Hospitals or Stations	Transferred: Readmitted for other Diseases	Transferred: Readmitted for Capital Operation	Remaining on the , 18
9. GUNSHOT WOUNDS OF THE LOWER EXTREMITIES. 4. With compound fracture of . . Femur . .								
Tibia only								
Fibula only								
Tibia and fibula .								
All three bones .								
5. Penetrating, perforating, or lacerating the several structures of the tarsus and metatarsus . . .								
6. Dividing or lacerating the structures of the toes								
10. GUNSHOT WOUNDS WITH DIRECT INJURY OF THE LARGE ARTERIES, NOT BEING AT THE SAME TIME CASES OF COMPOUND FRACTURE								
11. GUNSHOT WOUNDS WITH DIRECT PENETRATION OR PERFORATION OF THE LARGER JOINTS: With fracture of bone .								
Without fracture								
12. GUNSHOT WOUNDS WITH DIRECT INJURY OF THE LARGE NERVES, NOT BEING AT THE SAME TIME CASES OF COMPOUND FRACTURE								
13. SWORD AND LANCE WOUNDS OF . . . . —								
—								
—								
—								
14. BAYONET WOUNDS OF . —								
—								
—								
—								
15. MISCELLANEOUS WOUNDS AND INJURIES RECEIVED IN ACTION . . . . . —								
—								
—								
—								
Total Wounds and Injuries received in Action								

Application of the classification to all injuries inflicted in the field.—I have mentioned that some modifications of Taylor's classified forms were made when the revised regulations for the army medical service were issued in 1859. Originally, the 'descriptive numerical return' was specially prepared for use as a hospital return; that is, for use only after the wounded men had been admitted into a hospital having more or less of a fixed character, and when they had been placed under permanent hospital treatment. But it was thought necessary by those who framed the revised regulations, that, besides this application of it, a return, classified in the same way, of all the injuries received in each action should be prepared, as soon afterwards as possible, and sent by all surgeons in charge of bodies of troops to the principal medical officer.[8] While maintaining the same general arrangement, it was necessary for this purpose to alter the headings of the separate columns. Instead of being employed for showing the changes which might occur among the patients under hospital treatment, the columns were now used for indicating the nature of the missiles, or weapons, by which the several regional and special injuries had been inflicted in action. This reduced the number of classes from 15 to 12; the injuries of classes 13, 14, and 15—'Sword,' 'Bayonet,' and 'Miscellaneous' wounds—being tabulated in three separate columns of the return.

The return was also framed to include the deaths directly consequent on the injuries inflicted in each action—all distributed regionally, and according to their causes, in just the same manner as the injuries of those who survived to come under surgical treatment. I suppose this was something intended to be aimed at, rather than expected to be carried into execution, at least, in any but very minor engagements. It is no small matter, even with the best arrangements, and with a well-organised division of labour, to obtain a fair approach towards accuracy in enumerating the number of the wounded, and the nature of their injuries, shortly after the conclusion of a battle; to ascertain and define the injuries of those killed on the field, under ordinary circumstances, is impracticable. The relatively few medical officers available on such occasions have not time enough to attend properly to the wants of the living wounded; much less any to spare for determining the particular injuries of the dead, who often lie very widely scattered over the ground where the troops have been engaged, and its vicinity. Unfortunately the return was so framed that unless this information were given, the document, purporting as it did to include 'the total wounds and injuries' inflicted in a given action, would always be an incomplete, and so far, an erroneous one. This might have been avoided, by arranging a separate return for the injuries of those who had died on the field before receiving surgical aid; with instructions for it to be filled up whenever circumstances admitted of the required information being obtained. This could probably

be done on all occasions of comparatively slight engagements, attended with small numbers of casualties. The classified return of deaths on the field of action is now, however, discontinued altogether; only a return of those which occur in hospital, in consequence of injuries received in action, being required by recent regulations. This information is to be furnished in the 'Weekly Return of Sick of Troops on Active Service;' in which, also, the classified return of wounds and injuries received in each action during the week is to be embodied.

The classified return, authorised by the regulations of 1859, for indicating the admissions into hospital and their results, was not altered in any material respect from the original return elaborated by Inspector-General Taylor. The chief difference is that the distribution of the injuries is limited to twelve classes, as it is in the return of casualties in action, last described; the incised, punctured, and miscellaneous injuries being classified in the same manner, but shown in a separate sheet from those caused by gunshot, instead of being tabulated in one and the same return under additional classes.

Inspector-General Taylor appended to his classification of injuries a form of numerical return for showing the capital operations performed in consequence of them, and their results; this also, with a trifling addition, was adopted in the Revised Army Medical Regulations.

The following are the forms of the three descriptive returns—(1) for enumerating and distinguishing the injuries received in action; (2) for showing their hospital results; and (3) the capital operations they may have led to—as they were arranged in the army medical regulations of 1859, and ordered to be furnished by all medical officers in charge of corps and hospitals.

1 CLASSIFIED RETURN OF WOUNDS AND INJURIES RECEIVED IN ACTION ON THE ______

N.B.—Separate forms should be used for (1) *Officers and for* (2) *Non-Commissioned Officers and Men.*

[*This Form may be used for various purposes where Returns of Wounds and Injuries are to be made, the headings being altered according to circumstances.*]

Regions of the Body Wounded or Injured	Admissions With Wounds or Injuries								Deaths Consequent on the foregoing Wounds and Injuries							
	Total Wounded or Injured	Projectile or Weapon by which the Wounds or Injuries were inflicted							Among Total Wounded or Injured	Projectile or Weapon by which the Wounds or Injuries were Inflicted						
		Cannon Ball	Shell	Grape Shot	Rifle, Musket, Pistol Ball	Sword, Lance	Bayonet	Other or undetermined means		Cannon Ball	Shell	Grape Shot	Rifle, Musket, Pistol Ball	Sword, Lance	Bayonet	Other or undetermined means
ALL WOUNDS AND INJURIES.																
1. Wounds of the Head																
2. Wounds of the Face																
3. Wounds of the Neck																
4. Wounds of the Chest																
5. Wounds of the Abdomen																
6. Wounds of the Back and Spine																
7. Wounds of the Perineum and Genital and Urinary Organs, not being Wounds of the Peritoneum .																
8. Wounds of the Upper Extremities . . .																
9. Wounds of the Lower Extremities . . .																
10. Wounds with direct injury of the Large Arteries, not being cases of compound fracture . .																
11. Wounds with direct penetration or perforation of the Large Joints																
12. Wounds with direct injury of the Large Nerves, not being at the same time cases of compound fracture																

N.B.—The Classification will be continued by the expansion of each of these 12 *heads, so as to show the precise character of the Wounds and Injuries.*

2. CLASSIFIED RETURN OF WOUNDS AND INJURIES OF EVERY KIND RECEIVED IN ACTION ABROAD.

Admitted into the Hospital of __________ between the _____ of ________ and ______ of _________, 18____

N.B.—*Separate Forms should be used for* (1) *Officers and for* (2) *Non-commissioned Officers and Men.*

[*A separate Form may be used for Gunshot Wounds as distinguished from other Wounds.*]

Regions of the Body Wounded or Injured	Remained on the ____, 18	Since admitted	Amputations: Primary	Amputations: Secondary	Excision	Other Operations	Died	Discharged to Duty	Transferred: To other Hospitals	Transferred: To England	Remaining on the ____, 18
ALL WOUNDS AND INJURIES											
1. Wounds of the Head											
2. Wounds of the Face											
3. Wounds of the Neck											
4. Wounds of the Chest											
5. Wounds of the Abdomen											
6. Wounds of the Back and Spine											
7. Wounds of the Perineum and Genital and Urinary Organs, not being Wounds of the Peritoneum . . .											
8. Wounds of the Upper Extremities											
9. Wounds of the Lower Extremities											
10. Wounds with direct injury of the Large Arteries, not being cases of compound fracture											
11. Wounds with direct penetration or perforation of the Large Joints											
12. Wounds with direct injury of the Large Nerves, not being at the same time cases of compound fracture . .											

N.B.—*The Classification will be continued by the expansion of each of these heads, so as to show the precise character of the Wounds and Injuries.*

8. RETURN OF CAPITAL OPERATIONS.

			Remained on the ——, 18	Since Admitted	Died	Discharged Cured	Transferred			Remaining on the ——, 18
							To other Hospitals or Stations	Readmitted for other Diseases		
Amputations.	Upper Extremities.	Shoulder-joint								
		Arm								
		Fore-arm								
		Thumbs								
		Fingers								
	Lower Extremities.	Hip-joint								
		Thigh — At upper third								
		Thigh — At middle third								
		Thigh — At lower third								
		Leg								
		Ankle-joint								
		Medio-tarsus								
		Tarso metatarsus								
		Toes								
Excisions.	Upper Extremities.									
	Lower Extremities.									
Trephining										
Ligature of Arteries										
Total										

As it will not be possible for the surgeons attached to regiments, under the new arrangements which have been described in the previous section of this work, to procure the means of filling up the returns of casualties in action, it must devolve on the surgeons in charge of the field-hospitals to furnish the required information. The medical officers in charge of the bearer companies may, per-

haps, find the means occasionally of classifying the wounds of those who have died on the field without hospital treatment. The information, required for the second and third returns, must be supplied by the medical officers in charge of the intermediate and general hospitals of the second and third zones of surgical help.

Those who care to study and compare the classification which has now been described with other systems will, I believe, find it to be the best essentially, as well as the most convenient for use in collecting statistics of gunshot injuries in the field. I have elsewhere suggested one alteration in its general outline, with the view of obtaining more complete uniformity in the plan, viz., to abstract class 10, 'wounds of large arteries,' and class 12, 'wounds of large nerves,' and to transfer them to the list of subdivisions in classes 8 and 9—wounds of the 'upper' and 'lower extremities.' The tabulation of wounds of important arteries and nerves of other regions, as of the face and neck, is already provided for in the subdivisions of the classes comprehending those regions. By the means suggested, the classes would be reduced from twelve to ten in number. All of them would then be regional; and all the orders, or subdivisions, structural. If this suggestion were adopted, classes No. 8 and No. 9 would become subdivided as follows:—

8. GUNSHOT INJURIES OF THE UPPER EXTREMITIES.	1. Simple flesh contusions and Wounds	Slight
		Severe
	2. With injury of large blood-vessels	
	3. With injury of large nerves	
	4. With contusion and partial fracture of long bones, &c.	
	(The remainder as in Taylor's Classification)	
9. GUNSHOT INJURIES OF THE LOWER EXTREMITIES.	1. Single flesh contusions and Wounds	Slight
		Severe
	2. With injury of large blood-vessels	
	3. With injury of large nerves	
	4. With contusion and partial fracture of long bones	
	(The remainder as in Taylor's Classification)	

Alterations of certain headings.—Some of the terms in the headings of the 'Classified Return of Wounds and Injuries received in Action,' as ordered by the regulations of the year 1859, have now become obsolete. I refer to the names of the projectiles by which the wounds may be inflicted. 'Cannon Balls' no longer exist in the British service, nor, indeed, are any solid shot, like the cannon balls of old times, now employed in field artillery. The term is not used in any technical work relating to ordnance. The term 'grape shot' has also become practically obsolete since rifled ordnance took the place of the former smooth-bore guns. Lastly, rifles have been everywhere substituted for the muskets formerly in the hands of soldiers of the line.

Another point, susceptible of improvement, was that incised and punctured wounds were mixed together in the column headed 'Sword' and 'Lance.' The following arrangement is more scientifically, as well as more technically, correct, and it has been

adopted in the last form of 'Weekly Return of Sick of Troops on Active Service,' viz., 'W. O. Form, No. 294A':—

Total Wounded or Injured	Projectile or Weapon by which the Wounds or Injuries were inflicted					
	Gunshot or Shell	Rifle, Pistol, or Smaller Shot	Explosion of Gunpowder	Sword or Sabre	Lance or Bayonet	Other Injuries

These headings will, no doubt, be employed in all future statistical returns in which it is required to distinguish injuries according to the projectiles, or weapons, by which they have been caused.

Other sources of statistical information on the injuries of warfare. Before concluding the remarks on what has been done in this country towards collecting scientific professional statistics of the injuries from war by classified numerical returns, as well as for establishing a definite system on which the surgical results of future wars, in which this country may happen to be engaged, can be compared with the results in those which have been previously recorded, I may mention some other official documents by which information on the subject is afforded, and by which the professional statistics, just described, may be checked. These are the monthly, quarterly, and annual professional returns and reports from medical officers in charge of hospitals; the special return which every principal medical officer of an army in the field is required to furnish to the Director-General, exhibiting the sickness, casualties in action, and loss from invaliding and other sources, which have occurred in the force from the commencement to the termination of its employment on active service; the nominal returns of killed and wounded furnished by corps to the Adjutant-General's Department; the nominal returns of those who die in hospital to the medical department; and, lastly, the documents connected with the invaliding of disabled soldiers, and with the pensions awarded to officers and men for disabilities, in which more or less of professional information bearing on the nature of each case is included.

Advantages of the foregoing classification.—The advantages of the system of classification used in collecting returns of injuries in time of war in the British service, are the following. The attention of surgeons is forcibly called by it to all the most important distinctive characters of the various injuries that are likely to be brought under their care. If any special complications of wounds occur that are not already noticed in the classification, they can be readily added without affecting other parts of the return. Facilities are afforded by it to medical officers, for rapidly recording,

classifying, and tabulating the injuries through the printed forms in which the classification is issued to them; and it also gives facilities to the authorities for collating, uniting, and adding up together in general statistical tables, the information transmitted to them by the recording surgeons. The professional observers and operators in the field, and those in the general hospitals in rear, all classify the injuries under their care on one uniform plan; and it is the same as the one on which the complete statistics will be ultimately shown. The system is thus one of a general division of labour among the whole body of army medical officers, including not only the executive and administrative officers in the field, but also those engaged in the official duties of the Head-Quarters in London.

The statistics of the injuries inflicted in the wars in which different countries have been engaged, have been collected and published only in rare instances. The statistics of those which have been made public—viz., those of the Crimean War, Wars of 1859 and 1870–71 in France, and the War of the Rebellion in the United States—have been gathered together in the first instance by different methods, and none according to the system of classification which has been described. I have elsewhere compared the respective merits of these systems, and have attempted to indicate some of the advantages that might be expected to accrue to military surgical science, if these differences could be got rid of, and a common agreement be come to in different countries for classifying the injuries of war, the surgical operations they lead to, and their results, on one general system.[9] The accomplishment of this object is very desirable, if it were only to enable the professional statistics of one country to be easily and reliably compared with those of other countries.

SECTION XI.

STATISTICS OF GUNSHOT INJURIES IN WARFARE.

CHAPTER I.

PROPORTION OF HITS TO SHOTS FIRED IN WARFARE.

The increased velocity impressed upon projectiles discharged from the firearms of recent years, and the twofold effect of this increase, viz., greater destructive power within certain distances, and a maintenance of destructive energy beyond the ranges at which former weapons were capable of inflicting wounds, have been elsewhere remarked upon. But in practically applying these facts to a calculation of the number of wounds likely to be actually caused by modern firearms and missiles, it is not to be forgotten that, in proportion as the arms are improved, the military arrangements are changed with a view to counteract the purposes for which these improvements are invented. If, on the one hand, the range of rifled small arms be greatly increased, efforts will be made, on the other, by changes in tactics, by manœuvring the troops at greater distances, by advances in more extended lines and open order, by special employment of artillery, and similar military expedients, to neutralise the advantages which the rifles give to the infantry soldiers who are armed with them. Remembering these circumstances, and the vastness of the number of troops who are occasionally brought into opposition against each other in European warfare, with the large space of ground they occupy, we need not expect that the ratios of hits to shots, in a great battle regarded as a whole, will be much, if any, greater than it has been in previous wars. The effects produced, indeed, may appear to be even less, in proportion to the amount of ammunition expended, than they used to be. This will especially be the case when the number of troops held in reserve and out of range of fire is very large, and when in making the calculation, as is sometimes done, the general proportion of hits is distributed through the entire force.

Among particular small bodies of troops that happen to be

brought into opposition within limited distances of each other, the effects of the increased force of impulsion, and rapidity of fire, of the new firearms are manifested by a great increase in the numbers that fall killed or wounded, and in a reduction of the time during which these casualties occur. A large proportion of the shots fired under the circumstances named not only act with fatal accuracy on the individuals first struck, but many of them inflict wounds on several individuals in succession.

Accidental circumstances which affect the ratios in question.—The relative proportions of hits to shots in battle are caused to vary by a number of accidental conditions, such as the nature of the military operations, the conformation of the ground, and other circumstances. Different kinds of weather even, by affecting the state of the soil as to its hardness or softness, have been observed to exert an influence on the results under consideration. The heavy rain which fell during the night of June the 17th, 1815, lessened the number of wounds which would otherwise have been inflicted in the great battle of the following day; for, in consequence of it, solid shots, it has been recorded, seldom rose after touching the ground. Shells, too, buried themselves in the soft earth, and, when they sank deeply, generally failed to explode; while, if they lodged more superficially and then exploded, their fragments were greatly shorn of their power to inflict severe injuries. Similarly, in describing the action at the Taku Forts, at their capture in August 1860, Inspector-General Dr. Muir, the Principal Medical Officer with the British force, wrote:—'Fortunately the ground was soft, and the balls generally buried themselves without rolling or ricochetting, or many more lives and limbs would have been sacrificed.' As an example of an opposite condition, the severe winter of 1870–71, and the frozen hard ground which was the result of it, proved favourable to the Germans in their war against France; for, as the shells fired from their field guns were all percussion shells, they rarely missed explosion, and the number of wounds among the French troops was greatly increased in consequence.

The nature of the warfare, special features of the country in which it is carried on, and especially the relative positions of the combatants as regards conspicuousness and exposure, must always be taken into account in estimating the effects of particular weapons. Under some circumstances, the rudest muskets may produce more hits than the most perfect rifles, when opposed to each other. In bush-fighting especially, if the men on one side become exposed on open ground, this difference may be very marked. On January the 24th, 1865, a force of more than a thousand men of all ranks, under Lieut.-General Cameron, moved across the Kai-iwi river, and took up a position at about nine miles' distance from a native village called Nukamaru. Shortly after the arrival of the force,

the Maories made an attack on the picquet which was advanced to occupy this village, and maintained a desultory fire upon it all night. On the English side a staff officer was mortally wounded, three men of the 18th Regiment were killed, and six were wounded. The part of the British force engaged numbered 250 men, and, though they expended 7,000 rounds in addition to the 60 rounds of ball cartridge carried by each man in his pouch, altogether more than 20,000 rounds, they did not succeed, it was believed, in killing or wounding one of the enemy. The Maories fired from under cover of thick bush and trees, while the British troops were exposed on comparatively open ground. The enemy was invisible in the dense bush, while the white belts of the British soldiers formed good marks for them to aim at. Had both been alike exposed, a very different result would have ensued; as was proved, when the Maories were brave enough to advance and attack the main body of the troops on the open ground, in the course of the following day.

The colour of the clothing of troops is said to influence the number of hits under certain circumstances, as in skirmishing and in firing at long ranges, even when the circumstances of light and general exposure are similar. Colonel Hamilton Smith made some extensive experiments to ascertain the vividness of impression caused by differently coloured objects, especially objects of the colours of some leading military uniforms, and their consequent liability to be hit when employed as targets. After taking all necessary precautions to ensure similarity of conditions in his trials, he came to the conclusion that the proportionate liability was: bluish-grey, 5; rifle green, 7; red, 12. Mr. White Cooper has mentioned, on the authority of Captain Nelson, Royal Engineers, that the day before the battle of Vittoria, a Portuguese rifle company under Captain Derinzy, dressed in earthy brown, and a company of British fusiliers of equal strength, dressed in red, had to dislodge some French troops from a bridge. The two companies were equally exposed at the skirmish; and, after it was over, it was found that the loss of the British was as 2 to 1 to that of the Portuguese. This was attributed to the much more conspicuous mark afforded to the French by the red clothing of the British, than by the brown clothing of the Portuguese. When troops dressed in scarlet are moving in masses, the imposing array, and the striking impression excited by such a bright colour in contrast with other ordinary colours, may have a moral effect upon the enemy of an advantageous character to the wearers; but, as regards the chances of being hit when a distinct aim is taken by an individual marksman, the scarlet object, relatively to a similar object in bluish-grey, according to the experiments above mentioned, will incur a greater liability to be hit in the proportion of 12 to 5.

Recorded ratios of hits to shots fired.—It is not often that reliable information can be got as to the exact number of projectiles fired, so as to compare them with the number of wounds inflicted in particular battles or wars. One or two examples will suffice to show that the numbers of wounds have hitherto been very small in proportion to those of the projectiles fired.

According to Drinkwater's Diary of the Siege of Gibraltar, the enemy threw into the garrison, between April 12, 1781, and the following February, 258,387 cannon shot and shell, all of a heavy description. The total number of killed and wounded during the siege amounted to 1,341 (870 of these having been only slightly wounded, and having subsequently recovered), so that nearly 200 shot and shell were fired for every man struck. Were the calculation made of the number of missiles, that is, of the separate fragments into which the shells burst, the proportion would probably be nearer 1,000 missiles for every man struck.[1]

The proportion of hits to shots fired in bombardments appears to be remarkably small even at the present day. Lieut.-Colonel Prevost, of the French Engineers, has stated that during the late Franco-German war, at the bombardment of Mézières, which lasted 38 days, and where there was a population of 65,000 persons, the number of projectiles fired was 193,000, while the number of killed was 300, and of wounded 800; that, at the bombardment of Bitche, lasting 14 days, the population being at first 2,400, but subsequently 640, from 20,000 to 25,000 projectiles were fired, while the number of killed was 8, and of wounded 7; at Phalsburg, with a population of 2,000, from 8,000 to 9,000 projectiles were fired, killing 7 and wounding 15 persons; at Verdun, the population being 9,000 persons, 33,000 projectiles were fired, killing 7, and wounding 22; at Thionville, with a population of 4,000 in the place, the bombardment lasting 53 hours, and from 25,000 to 30,000 projectiles being fired, only 2 were killed; while at Longwy, with 200 persons in it, more than 30,000 projectiles were fired, yet no one was either killed or even wounded.[2]

In mixed warfare, too, the number of hits appears remarkably small in proportion to the number of projectiles fired. Dr. Chenu states, in his history of the Crimean Campaign, that the number of projectiles consumed, while it lasted, was 89,595,363. He obtained his information on this subject from the artillery and engineer reports of the different nations engaged in the war. This number includes all kinds of projectiles, great and small. He has also shown that the numbers of killed and wounded in action among the troops of the five armies engaged, Russian, French, English, Piedmontese, and Turks, including in his calculations all the engagements in the open field as well as the siege operations, amounted to 175,057. After deducting from these latter figures the numbers killed and wounded by cutting and stabbing weapons, by explosions

of powder in magazines and mines, and by other causes, and taking into account the number of separate missiles in certain composite projectiles, such as grape shot, he has come to the conclusion that about 1,000 projectiles, great or small, were fired for every man killed or wounded.

According to the report of General Rosencranz, of the United States, on the battle of Murfreesborough, it required 27 gunshot and 155 musket balls to hit one man on that occasion. It has been a common observation among military men, with regard to the Franco-German War of 1870–71, that a ton of iron was expended for every man killed. This has been, probably, a mere verbal expression without any definite basis; but it sufficiently shows the prevailing notion regarding the smallness of the number of hits to the amount of shot and shell fired. While the war was in progress the enormous fire of artillery on both sides, and the destructive nature of the shell projectiles employed were the theme of constant observation; yet the 5th section of Fischer's statistics shows that in the Prussian and North German armies only 48 officers and 647 men were killed, and 276 officers and 4,113 men wounded, by shell fragments. The amount of loss must be so out of proportion to the amount of iron discharged as to seem almost to warrant the popular remark just now mentioned.

General conclusion on the subject.—The probable truth is, as mentioned in the beginning of the chapter, that if the numerical force of the whole army operating in the field during a given war be taken as the basis, and the total number of projectiles discharged and of casualties produced by them in this force be then compared together, the ratio of hits to shots fired will not be found to have been much changed by the improvements effected in modern projectiles; but, if similar comparisons be instituted with regard to special sections of the army—particular corps, or detached bodies of troops, which have happened to be brought into close collision in the open field—the effect of the increased precision and destructive power of the new weapons will then be made manifest by a far greater proportion of casualties to the number of shots fired, than has been known in any former experience under corresponding circumstances.

CHAPTER II.

RATIOS OF WOUNDS TO PARTICULAR PROJECTILES IN WAR.

There are no reliable statistics, so far as I am aware, of the total number of injuries severally inflicted by the different kinds of projectiles employed during any war, or in any particular battle fought

in the open field. The nature of the injuries inflicted on those who have been killed outright by the projectiles, has never been ascertained with sufficient accuracy for the supply of this information. In the instances mentioned in the previous chapter, in which the number of projectiles and the number of casualties resulting from them have been placed on record, no proper numerical comparison can be established between the actual wounding effects of different descriptions of projectiles; for, in the siege operations mentioned, the projectiles used would be confined almost exclusively to the heavier kinds of shell and shot; and, in the other instances, in which projectiles of all kinds were employed, the facts necessary for distinguishing between their different effects have not been collected.

Relative number of wounds by gunshot.—The mass of metal contained in a solid shot discharged from a field gun, or gun of position, the immense force by which it is propelled, and the great range of its flight, might well lead to a supposition that such a shot would occupy the first rank among projectiles in respect to destructive effects. It might at first be imagined that whole ranks of men, one after another, for long distances would be mowed down by it, when armed with its usual amount of speed. This does not appear to have been the case, however, during the period when solid shot were the kinds of projectiles in general use with guns.

According to the account of Buonaparte, the French army expended 220,000 cannon balls during the battles fought from the 16th to the 19th of October, 1813, at and near Leipsic. The number of musket shots and other projectiles has not been recorded. The number of the allies who were killed and wounded throughout these engagements, was 59,000 at the outside. The largest part of this number were no doubt wounded by musket bullets, but if no other projectiles but cannon balls had been used during these battles, the numbers mentioned would show that only one man was struck for nearly every four (3·7) gun-projectiles fired.

Whether it was from their curvilinear flight, or their tendency to bound to great heights and distances on striking the ground, the physical consequences, regarded numerically, which resulted from the use of spherical gunshot, were by no means commensurate with the moral effects produced by their discharge. If such a shot came into collision with a soldier, the stroke would be fatal to life or limb, but the number of similarly fatal injuries, and of others of less gravity, that would be produced by the bursting of a shell, or by a single discharge of canister or grape among a body of troops, under circumstances equally favourable to the several sorts of projectiles named, would be numerically far greater.

Wounds from different projectiles brought under treatment.—Although there are no means for tabulating the relative propor-

tions of injuries inflicted by the particular projectiles employed in campaigns, the numbers of wounds caused by different kinds of shot which have been admitted into hospital for treatment, have been recorded on various occasions with tolerable exactness.

Out of 1,657 British troops who were wounded by gunshot and other projectiles, and admitted into hospital after the assault on the Redan, Sebastopol, on September the 8th, 1855, 1,003 had been hit by musket bullets, and 654 by shell, grape, and round shot.[3] These figures give a percentage of 60·53 by musket bullets, and 39·47 by all other kinds of projectiles. Of the two divisions actually engaged in the assault, the numbers were: 916 wounded by musket bullets, or 63·17 per cent.; 534 wounded by grape, round shot, and shell, or 36·82 per cent.

Out of 34,306 wounds admitted into the French ambulances and hospitals during the Crimean War, all of which are tabulated by Dr. Chenu according to the bodily regions wounded, it appears that 13,876 were caused by musket bullets, 694 by round shot, 11,423 by grape-shot and shell, and 7,495 by explosions of mines, magazines, and other similar sources. The remainder were wounds from cutting or stabbing weapons. It results from this statement that the wounds by bullets averaged 53·4 per cent., while the wounds from grape, round shot, and shell, amounted to 46·6 per cent. The wounds from round shot alone averaged only 2·7 per cent.[4]

The proportions differed very materially during the Italian campaign of 1859. The discrepancy is, no doubt, to be explained by the different nature of the military undertakings in which the troops were employed on the two occasions. During the Crimean War, the largest proportion of the wounds inflicted occurred in the siege operations before Sebastopol, and were received by the besiegers either in the trenches or during the assaults, when the projectiles employed by the Russians consisted principally of shells and grape. During the Italian campaign, on the other hand, there were no siege operations; all the principal engagements occurred in the open field.

There is no general table in Dr. Chenu's statistical history of the Italian Campaign which shows the kinds of projectiles by which the wounds were inflicted during the war, but, in the separate tables of wounds according to regions, the distinction is made between those which resulted from bullets, gunshot, shell fragments and grape. The wounds caused by weapons not depending on gunpowder for their action (armes blanches), or derived from other sources, are shown in separate columns. Putting together the wounds caused by projectiles, the numbers are respectively 14,484 by bullets, 159 by large projectiles, and 740 by shell fragments and grape, forming a total of 15,383 gunshot wounds

presented at the ambulances and hospitals. The wounds by bullets were therefore 94·2 per cent., those by gun projectiles 1·0 per cent., and those by grape and shell fragments 4·8 per cent. of the total number of gunshot wounds inflicted. In both wars, the Crimean War with its long siege of Sebastopol, and the Italian War with its great battles on the open ground, the large preponderance of wounds caused by musket shot, and the small ratio of the wounds caused by gunshot, are noticeable features.

Experience of the Franco-German war.—During the late Franco-German war the 'boulet,' or solid gunshot, disappeared from the French statistical returns of battles in the open field. There is only one table in Dr. Chenu's statistics of this campaign which particularises the projectiles or weapons by which the wounds were caused. This is a table, furnished by Dr. de Melun, of 551 wounded received from Gravelotte and treated at the ambulance established in the farm of Mogador. Of the 551 wounds 100 were caused by fragments of shell, 405 by bullets, 34 by sabres, and 12 by lances. Among the 505 gunshot wounds in this instance the bullet wounds constituted 80·19 per cent., the wounds by shell fragments 19·80 per cent. of the total number. This partial observation shows a larger proportion of wounds from shell fragments than the general experience among the Germans. According to Fischer's tables, out of every 100 officers and soldiers of the Prussian and North German armies hit by projectiles, 91 were struck by rifle shot and 9 only by shell splinters.[1]

As the proportion of field guns to the strength of particular bodies of troops is being largely increased in most armies,—the Germans being said to be doubling them in theirs, as compared with the numbers employed by them at even so late a period as that of the Franco-German War—it seems probable that the proportion of shell wounds to rifle-shot wounds may be increased in future wars in a corresponding degree.

CHAPTER III.

NUMBERS AND RATIOS OF CASUALTIES, AND PROPORTIONS OF KILLED TO WOUNDED, IN VARIOUS BATTLES

The usual proportion of casualties among troops engaged in war, the ratios of killed to wounded, and the relative proportions of particular wounds, are subjects which involve many matters of interest, not merely to officers in immediate command of armies, but also to those upon whom the duty devolves of providing and maintaining reserves to fill up the gaps occasioned by the service

\

in which the troops are engaged. But it is also a subject that particularly concerns those who are in charge of the medical departments of armies; for the usual proportions of such casualties, and their kinds, must be considered, when the amount of hospital stores, hospital transport, and surgical attendance, necessary to be provided in the first instance for a campaign, has to be calculated, and also when preparations have to be made for the reception and care of the wounded that may result from an impending general engagement with the enemy.

On this subject I appended some tables and remarks to my treatise on the Transport of Sick and Wounded Troops, elsewhere referred to; and as the work is now out of print, it will probably be of service to transfer to this place the information there given, with such corrections and additions as subsequent inquiries have enabled me to make. By tabulating the ratios of casualties in some of the great battles of the last century side by side with those of later dates, it might be expected that an opportunity would be afforded for studying the influence in war of the changes which have taken place in military firearms; and, indeed, they are often employed for establishing comparisons on this head.

Explanation of different statements regarding losses in war.—It is necessary, however, to be aware that there are many sources of fallacy in the statements often made respecting the numbers of casualties in particular battles. Few inquiries are more difficult than those for finding the proper value of the figures in the numerical lists of casualties furnished by military commanders and historians, not merely as to former but also in regard to most modern wars.

The truth of this remark forces itself into notice in many ways. In the first place, on examining military records it is found that the stated numbers of casualties in particular battles vary very greatly according as different authorities are consulted on the subject. Serious discrepancies are met with alike as to the strength of the troops engaged, and as to the numbers and nature of the casualties. It is easy to trace, in some instances, on the part of the rulers on the vanquished side, efforts to curtail the extent of the calamity which has happened to their country; equally easy, also, to observe attempts on the part of the victors to exaggerate the injury which they have inflicted on their opponents. But not only are different statements as to the amount of loss incurred met with in the published accounts of the countries opposed to each other in the battles, the histories of which are inquired into, but they are found in the records of the same country. Without imputing dishonest or interested motives as one of the origins of these discrepancies, there are several fertile sources of contradiction in the mere manner in which the accounts of alleged facts have happened to be obtained and put on record. It may

be useful to point out a few of these causes of such conflicting statements.

In some instances, the number of men stated to have been killed in a particular action represents those actually killed during the fight, and left dead on the field; in other instances, those who have died subsequently, from the effects of their wounds, within varying periods, are included in the number of killed. The discrepancies which arise from this source become multiplied according to the number of days, or extent of time, which may have elapsed before the 'returns of deaths' have been collected and added up.

Errors as to the numbers wounded in battles arise in a similar way. The difference of a single day in the time of collecting the returns of casualties will cause an important difference in the sum of the number wounded on a given occasion.[5]

There is generally a praiseworthy desire to send off returns of casualties as early as possible after an engagement, in order to satisfy the anxiety for intelligence among the countrymen, as well as the relatives and friends, of the officers and men of which an army is composed. It is almost impossible, under the circumstances in which troops are usually placed at this time, to avoid numerous errors in making up the lists out of which the general returns of casualties are framed. In the columns of 'killed' are sometimes placed absentees who are either lying wounded in some of the temporary field-hospitals or who have strayed from their respective corps; in the columns of 'missing' or 'disparus' are placed some who, as afterwards proved, should have been accounted for in the columns of killed or wounded. Men with slight injuries appear in the first returns as wounded, but, joining their ranks for duty without entering a hospital, appear the next day in the lists of effective soldiers; and then, in order to balance the respective figures of 'strength' and 'losses,' they cease to be counted among the number of wounded. These are only a few among many sources which lead to differences in the sums total of casualties, in even comparatively slight engagements, as exhibited in the numerical returns collected shortly after the actions have transpired, and in those furnished at subsequent periods. Sometimes the early official returns, sometimes the rectified accounts, are quoted by writers, and hence some of the discrepancies which are met with in historical records on the subject. In great battles, especially in battles renewed for several successive days, the difficulties of procuring correct returns of the casualties and of their nature, are increased a thousandfold. As regards the forces which are beaten in the conflict, and driven away, the difficulties may, indeed, be said to be insuperable.

The term 'losses,' too, is employed with such various significations that it is frequently difficult to determine with precision

what its meaning is intended to be when it is employed in the accounts given of early battles by writers. Sometimes the expression seems to be used to indicate the number of casualties of all kinds, including killed, wounded, prisoners, and missing, that is, the loss in the effective strength from all causes; sometimes it includes only the killed and wounded; sometimes the 'losses' refer to no others but the deaths, the wounded being spoken of separately.

It is generally understood with regard to the numerical losses attributed to many Continental battles of the last, and early part of the present century, that large numbers of soldiers who died from disease induced by various causes during the movements of the armies, as well before as after the particular battles referred to, were accounted for by being included in the losses of the battles themselves.[7] The national and military feelings were less hurt by a large number of casualties being shown to have occurred in action with the enemy, than if they had been accounted for as the result of sickness brought on by fatigue and exposure; and, moreover, military and medical statistics were neither so strictly kept then, nor were such as were put forth so capable of being analysed, as they have been of recent years.

Proportion of casualties to troops engaged.—But whatever may be the difficulties in determining the number wounded in particular battles, the difficulty of ascertaining the ratio of casualties to those *actually engaged* in action is far greater. Yet this is the important point to be informed upon when trying to estimate the average amount of surgical dressings, transport, and other appliances required for the wounded of a stated force. The number of wounded that may result from an action in which only half or one-fourth of the army has been engaged as combatants, should be set down as the proportion of wounded to the strength, whatever it may be, of that half or fourth section of the army; not to that of the whole army, of which a part, though exerting, perhaps, an important military influence as a force in reserve, cannot fairly be reckoned in a computation of the ratio of wounds to combatants, as if it had actively participated in the fighting. Two divisions of the British army were not brought into the action on the Alma; in calculating the proportion of casualties to fighting men, the strength of these two divisions should clearly be separated from that of the forces which were engaged in the battle. It was estimated by no less an authority than General Von Moltke that 92,000 men who formed part of the Prussian army in 1866 at the battle of Königgrätz never fired a shot; these therefore, ought to be excluded from the number of combatants when estimating the proportion of hits to troops on that occasion. If they had taken an active part in the fighting, it is to be presumed that the number of hits would have been proportionately increased.

It is generally stated that the proportion of casualties in war has gradually diminished since the introduction of the improved weapons of recent years. In the journal of the United Service Institution for 1862 is an article in which, from this statement, the writer is led to question the general superiority of the rifle over the smooth-bore musket as a weapon of destruction in armies. In a portion of this paper the following are given as the ratios of casualties in particular battles:—'During the late Italian War both sides had rifles, the French had also rifled cannon. How was it that the mortality, the carnage, instead of being greater was actually much less than in any previous wars with the smooth-bore of old?

'At Austerlitz the loss of the French was 14 per cent. of their army, that of the Russians 30, that of the Austrians 44.

'At Wagram the French lost 13 per cent., the Austrians 14.

'At the Moskowa the French loss was 37 per cent., the Russian 44.

'At Bautzen the French lost 13 per cent., the Russians and Prussians 14.

'At Waterloo there fell of the French 36 per cent., of the Allies 31.

'And now at Magenta, on the 4th of June 1859, we find that the French lost 7 per cent., and the Austrians 8 per cent.

'And at Solferino the Franco-Sardinian army lost 10 per cent., the Austrian 8 per cent.'[8]

The same ratios were mentioned in the House of Lords in July 1868, in the course of a discussion upon the use of explosive bullets in war, by the Earl of Malmesbury, who said that he had received them from an officer connected with the French War Office. Lord Malmesbury also pointed out as a natural inference from the figures that, 'it must not be taken for granted that these new military inventions and improvements in military projectiles necessarily occasion a greater destruction of life than formerly occurred.' Statements having the same tendency have been put forth in another form. It has been said that the losses of the victors in the following great battles were:—At Waterloo, one-fourth; at Borodino, a third; at Talavera, an eighth; at Marengo, a fourth; at Inkerman, before rifle guns and breech-loaders were in use, a third; while at Magenta and Solferino the losses were only one-eleventh, and at Königgrätz, one-twenty-third.[9] It is well to state that these statistics and the deductions which have been drawn from them are, to say the least, very imperfect, and, in some respects, from this cause calculated to mislead. They show the proportions of casualties (the term 'losses' in most of the foregoing quotations evidently comprehends killed, wounded, and missing) not to the troops actually engaged, but to the strength of the entire army under command—not only the men actually on the battle

field, but also those detached, sick, and held in reserve; in short, to the whole army of which the troops engaged formed part. The percentages, too, are in certain instances materially influenced by the loss of men unwounded but taken prisoners, these being included in the column of missing.

The number of troops brought on the field in some battles is comparatively small, so that they are all actually engaged in the conflict; perhaps, too, for many consecutive hours. The Adjutant-General's 'Morning State' at Waterloo, on the 18th of June 1815, showed the strength of the British army to be 49,309. But twelve battalions of the army were detached at Courtrai, Brussels, Braine le Comte, Antwerp, and at other places; and a certain number were sick or wounded in hospital, prisoners, or missing. These being deducted, the numbers present on the field of Waterloo (officers, non-commissioned officers, and rank and file included) were reduced to 36,240. These 36,000 troops were exposed to fire from daybreak to night, and a large proportion of them were in repeated close conflict with the enemy. Hence the large ratio of casualties among them. Large as it was, however, it would almost amount to an absurdity to suppose that, had they been subjected to shot from the improved rifles and rifled guns of the present time for the same number of hours, instead of from the smooth-bore muskets and guns then in use, the number of killed and wounded among them would not have been vastly increased. Yet the inference which might be drawn from the remarks above quoted is that the carnage, instead of being greater, would actually have been less. At the present day the facilities of rapidly concentrating troops and their matériel are immensely increased. Such armies as were opposed to each other at Solferino and Königgrätz present numbers so enormous—in the former instance 298,358, in the latter 427,100 men under arms being said to have been brought together—that it becomes impossible for all the troops to be engaged in the battle. The firing, especially of the infantry, being restricted to almost directly opposite fronts, the bodies of troops acting as supports or reserves in such vast armies are almost necessarily excluded from active interference as combatants—as 'troops actually engaged.' But in estimating the comparative losses, as they have been in the quotations cited above, the strength of the whole army, including its reserves, appears in most instances to have been taken as one figure, and the casualties, which have really occurred in certain portions of that strength, in the particular bodies of troops brought to close quarters in the combat, to have been distributed amongst the whole. No deductions as to the qualities of the weapons employed on the different occasions referred to can be drawn from such calculations. As well might it be argued that clubs, swords, and lances were more destructive than fire-arms, because, as is well known to have been the case, the usual proportion of *injuries* to the number of

combatants was greater before the application of gunpowder to weapons of offence than it has been since; the real explanation being that in the battles of early times, when hotly contested, each individual came to be engaged in a hand-to-hand encounter in which one or other was sure to receive some sort of injury. It need hardly be remarked that the greater part of such injuries would be of a comparatively harmless character.

It is evident that, besides the nature of the weapons used, the particular circumstances of battles, whether engagements in the open field, assaults, or others, the tenacity of the respective opponents, the numbers actually brought into collision, the duration of the fighting, the nature of the casualties comprehended under the general term 'losses,' must all separately be considered before one battle can be properly compared with another as regards the destructive power of the weapons employed by the combatants. So far as the ratios above quoted go, they serve to show that when all the troops, not only those actually brought into action, but also those acting as supports and reserves, or otherwise on the strength of an army, are included, modern tactics, and the present facilities for bringing large masses of men together for military purposes, cause the chance of a casualty of any kind happening to each of the units composing that army to be considerably less than it was formerly; but, notwithstanding this general deduction, numberless facts, which it would be out of place to bring forward here, concur to prove, as regards the particular bodies of troops which are opposed to each other in actual fighting, that the number of severe wounds inflicted within corresponding periods of time is far greater than they ever were before the introduction of rifles and breech-loaders.

The following table has been put together to show the percentages of the various descriptions of casualties in certain great battles and wars of the last and present century.[10] It shows not merely the percentages of the general losses, but those of the killed, wounded, and missing respectively. Great pains have been taken to obtain the numbers on which the calculations are based from the most impartial sources, and, with regard to later battles, from the most reliable official returns. References to the authorities whence the strength and numbers of casualties named in the table have been obtained, will be found in the Appendix. Where blanks occur the necessary information could not be obtained from any of the accounts examined.

Table showing the Proportions of Killed, Wounded, and Missing in various Battles.

Battles	Nation	Strength	Numerical Losses: Killed	Numerical Losses: Wounded	Numerical Losses: Missing	Numerical Losses: Total	Percentage of: Killed	Percentage of: Wounded	Percentage of: Missing	Percentage of: Total Loss	Ratio of Killed to Wounded
Blenheim, August 13, 1704	British and Allies	56,000	5000	8000	0	13,000	9	14	0	23	1 to 1·6
	Gallo-Bavarians	60,000	12,000	14,000	14,000	40,000	20	23	23	66	1 to 1·1
Ramillies, May 23, 1706	British and Allies	60.000	1066	2867	0	3933	2	5	0	7	1 to 2·6
	Gallo-Bavarians	62,000	2000	5000	6000	13,000	3	8	9	20	1 to 2·5
Belgrade, August 17, 1717	Austrians	40.000	8000		...	8000	20		...	20	
	Turks	140,000	28,000		...	28.000	20		...	20	
Kunnersdorf, August 12, 1759	Prussians	40,000	8000	15,000	3000	26,000	20	38	7·5	65	1 to 1·9
	Russians and Austrians										
Austerlitz,[11] December 2, 1803	French	70.000	12,000		0	12,000	17		0	17	
	Austrians and Russians	84,000	26,000			26,000	31			31	
Maida,[12] July 4, 1806	French	7500	700	3300	0	4000	9·33	44·00	0	53·33	1 to 4·7
	English	5000	45	284	0	329	0·9	5·68	0	6·58	1 to 6·3
Wagram, July 6, 1809	Austrians	90.000	24.000		1000	25,000	27		1·1	28	
	French	140.000	25,000		7000	32,000	17		·5	22	
Talavera,[13] July 28, 1809	British	23,000	875	3913	652	5422	3·89	17·78	2·96	21·65	1 to 4·5
Albuera,[14] May 16, 1811	British	7530	988	3002	0	3990	13·12	39·86	0	52·98	1 to 3·0
Badajos,[15] March 17 to April 6, 1812 (whole siege)	British and Portuguese	21,784	1035	3787	0	4822	4·75	17·38	0	22·13	1 to 3·6
Badajos,[16] April 6, 1812 (assault)	British	10,200	651	2349	22	3022	6·40	23·03	·21	29·62	1 to 3·6
Salamanca,[17] July 12, 1812	British	25,381	336	2400	74	2810	1·32	9·16	·29	11·07	1 to 7·1
	Portuguese	17,518	287	1436	18	1741	1·61	8·20	·10	9·94	1 to 5·0
Moskowa, or Borodino, September 12, 1812	Russians	125.000	15,000	35.000	1000	51,000	12	28	·8	40	1 to 2·3
	French	120,000	9000	13.000	1000	23.000	8	11	·8	19	1 to 1·4
Bautzen,[18] May 20, 1813	Prussians and Russians	110.000	7500	16.000	0	23,500	7	14	0	21	1 to 2·1
	French	150,000	8800	18,000	0	26,800	6	12	0	18	1 to 2·2

Vittoria,[19] June 21, 1813	British and Portuguese	60,486	4626			4626	...	...	...	7·65	
	British	35,129	501	2807	0	3308	1·42	7·99	0	9·41	1 to 5·6
Leipzig,[20] October 16 to 19, 1813	Allies	300,000	17,000		0	47,000	16		0	16	
	French	171,000	15,000	30,000	15,000	60,000	9	18	9	36	1 to 2·0
Toulouse,[21] April 10, 1814	British and Allies	53,417	595	4016	0	4641	1·11	7·57	0	8·68	1 to 6·8
Waterloo,[22] June 18, 1815	British	36,240	1759	5892	807	8458	4·85	16·25	2·19	23·31	1 to 3·3
	Hanoverians	11,220	288	1124	816	2228	2·56	10·01	7·27	19·85	1 to 3·9
	German Legion	5824	306	866	209	1381	5·25	14·86	3·58	23·71	1 to 2·8
Alma,[23] September 20, 1854	English	21,480	362	1621	0	1983	1·68	7·54	0	9·32	1 to 4·4
	French	30,528	144	1197	0	1341	0·16	3·94	0	4·40	1 to 8·3
	Russians	60,000	1807	2821	1008	5636	3·01	4·70	1·68	9·39	1 to 1·5
Inkermann,[24] November 5, 1854	English	14,000	529	2286	0	2815	3·77	16·32	0	20·10	1 to 4·3
	French	41,019	229	1551	70	1850	0·55	3·78	0·17	4·51	1 to 6·7
	Russians	55,000	6062	9406	267	15,735	11·02	17·10	0·48	28·60	1 to 1·5
Crimean War,[25] September 20, 1854, to end of War	English	97,864	2755	12,094	0	14,849	2·81	12·35	0	15·17	1 to 4·4
	French	(?)	8250	39,868	0	48,118	...	...	...	...	1 to 4·8
Montebello,[26] May 20, 1859	French and Sardinians	8227	105	549	69	723	1·28	6·67	0·84	8·79	1 to 5·2
Magenta, June 4, 1859	French	48,090	657	3223	655	4535	1·37	6·70	1·36	9·43	1 to 4·9
	Austrians	61,640	1365	4348	4500	10,213	2·21	7·05	7·30	16·56	1 to 3·2
Solferino, June 24, 1859	French and Sardinians	135,234	2313	12,102	2776	17,191	1·71	8·95	2·05	12·71	1 to 5·2
	Austrians	163,124	2586	10,634	9096	22,310	1·46	6·52	5·70	13·68	1 to 4·5
Italian War,[27] of 1859 (whole war)	French	18[illegible],690	2536	19,672	1128	20,718	1·33	10·37	0·59	12·29	1 to 7·7
	Sardinians	(?)	1010	4922	12[illegible]8	7200	...	...	...	...	1 to 4·9
	Austrians	(?)	5416	26,149	17,306	48,871	...	...	...	...	1 to 4·8
Shiloh,[28] April 6 and 7, 1862	Unionists	63,000	1735	7882	3956	13,573	2·75	12·51	6·27	21·83	1 to 4·5
	Confederates	40,000	1728	8012	959	10,699	4·32	20·03	2·39	26·74	1 to 4·6
Antietam,[29] September 17, 1862	Unionists	87,164	2010	9416	1043	12,469	2·30	10·80	1·19	14·30	1 to 4·6
	Confederates	97,445	3500	16,399	6000	25,899	3·60	16·82	6·15	26·58	1 to 4·6
Murfreesboro',[30] December 31, 1862, to January 2, 1863	Unionists	43,400	1533	7245	2800	11,578	3·53	16·69	6·45	26·67	1 to 4·7
	Confederates	35,000	9000		2000	11,000	25·71		5·71	31·42	
Gettysburg,[31] July 1 to 3, 1863	Unionists	117,350	2834	13,709	6643	23,186	2·41	11·68	5·66	19·75	1 to 4·8
	Confederates	68,352	3500	14,500	13,621	31,621	5·12	21·21	19·92	46·26	1 to 4·1
Chickamauga,[32] September 19 and 20, 1863	Unionists	50,000	1644	9262	4945	15,851	3·28	18·52	9·89	31·70	1 to 5·6
	Confederates	53,000	2389	13,412	2003	17,804	4·50	25·30	3·77	33·59	1 to 5·6
Wilderness,[33] May 5 to 7, 1864	Unionists	100,000	2309	12,185	3893	18,387	2·30	12·18	3·89	18·38	1 to 5·2
	Confederates	(?)	2000	6000	3400	11,400	...	...	...	...	1 to 3·0

Table showing the Proportions of Killed, Wounded, and Missing in various Battles.—cont.

Battles	Nation	Strength	Numerical Losses: Killed	Numerical Losses: Wounded	Numerical Losses: Missing	Numerical Losses: Total	Percentage of: Killed	Percentage of: Wounded	Percentage of: Missing	Percentage of: Total Loss	Ratio of Killed to Wounded
United States War of Rebellion,[34] April, 1861, to May, 1865	Unionists	(?)	59,860	280,040	184,791	524,691	...	...	...	...	1 to 4·7
	Confederates	(?)	51,425	227,871	384,281	663,577	...	...	...	...	1 to 4·4
New Zealand War,[35] January 1, 1863, to February 15, 1866	British	7930	182	506	0	688	2·29	6·38	0	8·67	1 to 2·8
Prusso-Danish War of 1864[36] (5 months). (*a*)	Prussians	46,000	422	2021	0	2443	0·92	4·39	0	5·31	1 to 4·8
" . (*b*)	Prussians	16,000	422	2021	0	2443	2·63	12·63	0	15·26	1 to 4·8
" . (*c*)	Danes	12,000	678	1222	0	1900	5·65	10·18	0	15·83	1 to 1·8
Königgrätz,[37] July 3, 1866 (*a*)	Prussians	220,984	1929	6948	276	9153	0·87	3·14	0·12	4·14	1 to 3·6
" (*b*)	Prussians	129,000	1929	6948	276	9153	1·49	5·38	0·21	7·08	1 to 3·6
" (*c*)	Austrians and Saxons	215,028	5793	17,805	7836	31,434	2·69	8·28	3·64	14·61	1 to 3·0
" (*d*)	Austrians and Saxons	150,000	5793	17,805	7836	31,434	3·86	11·87	5·22	20·95	1 to 3·0
Weissenberg,[38] August 4, 1870	Germans	106,928	293	1082	153	1528	0·27	1·01	0·15	1·43	1 to 3·7
Saarbrück and Spikoren, August 6, 1870	Germans	119,033	862	3632	372	4866	0·72	3·05	0·31	4·08	1 to 4·2
Woerth, August 6, 1870	Germans	167,119	1628	7570	1444	10,642	0·97	4·53	0·86	6·36	1 to 4·7
Vionville, August 16, 1870	Germans	151,858	3289	10,282	1249	14,820	2·16	6·77	0·82	9·75	1 to 3·1
Gravelotte, August 18, 1870	Germans	278,131	4449	15,189	939	20,577	1·60	5·46	0·33	7·39	1 to 3·4
Sedan, September 1, 1870	Germans	190,239	1637	6485	912	9032	0·86	3·40	0·48	4·74	1 to 3·9
Orleans, October 11, 1870	Germans	56,553	170	662	87	922	0·30	1·17	0·15	1·62	1 to 3·9
Coulniers, November 9, 1870	Germans	38,951	69	533	621	1223	0·18	1·37	1·59	3·14	1 to 7·6
Amiens, November 27, 1870	Germans	52,430	181	1022	31	1234	0·34	1·95	0·06	2·35	1 to 5·7
Beaune-la-Rolande, November 28, 1870	Germans	91,405	110	645	118	873	0·12	0·70	0·13	0·95	1 to 5·8
Le Mans, January 10, 1871	Germans	123,749	289	895	118	1302	0·23	0·72	0·09	1·05	1 to 3·1
Lizaine, January 15, 1871	Germans	64,735	236	1078	227	1541	0·36	1·66	0·35	2·37	1 to 4·6
Franco-German War,[39] July 24, 1870, to April 1, 1871	Whole German Army. South German included	887,876	17,570	96,189	4009	117,768	1·97	10·83	0·45	13·26	1 to 5·4

General ratio of killed to wounded in war.—An examination of the foregoing table shows that the lowest ratio of killed to wounded occurred among the French troops at the battle of the Alma, viz.: 1 killed to 8·3 wounded; while the highest noted was among the Gallo-Bavarians, at Blenheim, where the killed and wounded were in nearly equal proportion. It is difficult to explain the small number of killed, relatively to the number of wounded, among the French at the Alma; but, at Blenheim, it is probable that a large proportion of the 14,000, who appear in the returns as missing, were wounded prisoners. If this surmise be correct, the ratio of the killed would be relatively lessened. It will be seen that in the greater number of battles, the ratio of killed to wounded is higher than in the former, and lower than in the latter instance. On summing up the ratios of killed and wounded in the whole of the battles and wars noted in the table, the mean ratio of the killed to the wounded will be found to be as 1 to 4·1; or, taking the aggregate numbers, the mean ratio of killed to wounded is 1 to 3·77. These ratios give nearly 20 killed and 80 wounded in every 100 casualties; and this, judging from the experience gained down to the present time, may be regarded as the approximate average likely to be met with in battles.

CHAPTER IV.

PROPORTIONATE AREAS OF THE PRINCIPAL DIVISIONS OF THE HUMAN BODY EXPOSED TO BE HIT IN WARFARE.

BEFORE examining the records of particular battles or wars with a view to determine the proportionate number of wounds inflicted in different parts of the body, I have thought it well to consider the relative areas of the several regions exposed to be hit by projectiles, in the case of a man facing the enemy.

Target area of the whole front of a soldier.—I am not aware that any perfectly reliable calculations on this head have been made, and many difficulties present themselves in attempting to obtain the information from actually measuring parts of the surface of the body itself. M. Quetelet has put down the whole outer surface of a large man, measuring a small fraction over 5 ft. 8 in. in height and weighing about 168 lbs., as 2,549·75 square inches; and Valentin, measuring his own body, his height being 5 ft. 3 in., and his weight nearly 120 lbs., found its whole superficial area to be 2,325 square inches. The target area of the full front of a man would of course be considerably less than half the total surface area, as the lateral aspects of the body would be no more

exposed than the back under the circumstances named. According to the observations noted in the last table of this chapter, it appears that the target area presented by the front of a well-proportioned man, 6 ft. in height, is a little over 1,000 square inches.

Target areas of particular regions of the body.—What is of most interest, however, to military surgeons, is the amount of target surface presented by particular parts of the body, or, in other words, the relative exposure of its different regions to be struck by projectiles in battle, supposing the missiles to be equally distributed. It is obvious that if one region presents double the target area of another, the expectation will be, all other things being equal, that, out of a given number of wounds, there will be twice as many in the former as there will be in the latter region.

It appeared to me that the required information might be obtained, with approximate accuracy, if a careful measurement were made of certain drawings of the human frame of acknowledged excellence. I therefore selected the following for the purpose, and I was interested in observing how closely the results of the several measurements agreed with each other.

Relative regional areas in drawings by Albinus.—There are two classical drawings of the human frame by Albinus[10]—better known in this country, perhaps, through the copies of them by Andrew Bell[11]—the one exhibiting the external form and muscular development of the full front, the other, of the side aspect of the body. These drawings have been accepted as standards of just proportions, and anatomical correctness. The relative amounts of superficial area presented by the principal divisions of these drawings were measured; both drawings being divided into squares, and each square being one-hundredth of a square inch in dimensions.

The following was the result obtained with the figure presenting a full front:—

Figure, full front.

Part of Body	Space Occupied	
	Absolutely in $\frac{1}{100}$ths of Square Inches	Relatively in percentages of the whole Surface
Head and Face . . .	167	5·2 per cent.
Neck	73	2·3 ,,
Trunk (Chest and Abdomen) .	902	28·1 ,,
Upper Extremities . . .	690	21·5 ,,
Lower Extremities . . .	1378	42·9 ,,
Total	Square Inches. 32·10	100·0

The measurements of the side view of the body, made by the same method, gave remarkably similar results. They were as follows:—

Figure, side view.

Part of Body	Space Occupied	
	Absolutely in $\frac{1}{100}$ths of Square Inches	Relatively, in percentages of whole Surface
Head and Face . . .	156	5·0 per cent.
Neck	90	2·9 ,,
Trunk	850	27·5 ,,
Upper Extremities . . .	670	21·7 ,,
Lower Extremities . . .	1324	42·9 ,,
Total	Square Inches 30·90	100·0

The mean of both figures gives the following results:—

Part of Body	Relation of area to that of the whole surface
Head and Face	5·1
Neck	2·6
Trunk	27·8
Upper Extremities	21·6
Lower Extremities	42·9
Total	100·0

Relative regional areas in Liharzik's figures.—A similar calculation was made by examining on the same plan the drawing of the external proportions of the human frame, front view, at the 300th month, in Dr. Liharzik's work on 'The Law of Increase in the Structure of Man.' This observation gave slightly different proportions. They were as follows:—

Part of Body	Relation of area to that of the whole surface
Head and Face	7·0
Neck	3·6
Trunk	30·3
Upper Extremities	19·7
Lower Extremities	39·4
Total	100·0

The variations appear to be due partly to the altered position of the head and neck, and partly to differences in the outlines of the figures. The relations of the two extremities in all the instances is alike; that is, the area of the lower extremity is just double that of the upper extremity in Liharzik's figure, as it was found to be on measuring the figures drawn by Albinus.

Regional areas of the Pythian Apollo and Farnesian Hercules.—The statue of the Pythian Apollo, measured in a similar manner, notwithstanding that the attitude differed from those in the preceding drawings, gave closely approximate results. The following percentages were calculated from a drawing of the front aspect of the Apollo, in Andran's plates of the proportions of the human body, the detailed measurements of which were taken carefully from the statue itself.[42] In this instance the head is turned so as to present the face sideways, and one arm is fully extended.

Part of Body	Relation of area to that of the whole surface
Head and Face	6·2
Neck	2·4
Trunk	30·3
Upper Extremities	19·9
Lower Extremities	41·2
Total	100·0

The front view of the statue of the Farnesian Hercules, in the same work, similarly measured, gave the following proportional areal contents:—

Part of Body	Relation of area to that of the whole surface
Head and Face	5·58
Neck	2·28
Trunk	28·64
Upper Extremities	22·00
Lower Extremities	41·49
Total	99·99

Relative regional areas in one of Marshall's physiological diagrams.—Surgeon Moffitt, when Instructor of the Army Hospital Corps, measured for me, in a similar manner, the target area presented by one of the large figures, six feet in height, of Marshall's 'Physiological Diagrams.' These life-size drawings were used by him in instructing the men under his charge. The following were the results of Dr. Moffitt's measurements:—

Part of Body	Target area in square inches	Relation of area to that of whole body
Head and Face	56·25	5·60
Neck	22·50	2·24
Trunk	276·00	27·53
Upper Extremities	226·00	22·53
Lower Extremities	422·00	42·10
Total	1002 75	100·00

Mean of the foregoing measurements.—The percentages of the areas of the five principal divisions of the body, shown in this last table, closely correspond with those derived from taking the mean of the measurements of the two anatomical figures of Albinus. On taking the mean of the measurements of the five figures before named, viz., those of Albinus, Liharzik, the Apollo and Hercules, and that by Marshall, the following is the result:—

Region of Body	Percentage of the whole target area of the body
Head and Face	5·89
Neck	2·62
Trunk	28·91
Upper Extremities	21·14
Lower Extremities	41·41

These numbers, therefore, may fairly be taken as showing the normal relative amounts of target area presented by the different bodily regions of a soldier facing his enemy in battle, under circumstances of full and equal exposure to shot.

CHAPTER V.

RATIOS OF WOUNDS IN PARTICULAR REGIONS OF THE BODY IN WARFARE.

Variations in the regional distribution of wounds in warfare.—The proportionate numbers of wounds inflicted in battle in particular regions of the body are caused to vary by a great number of circumstances. The nature of the military operations—whether they consist of sieges and assaults, of battles on open plains, over rugged and broken ground, in forest or bush—exerts an important influence in this regard. In siege operations, the parapets of the trenches and covering objects of saps screen the lower parts of the body, and the number of wounds in these situations will be proportionably lessened; in engagements in the open field, on the other hand, it might fairly be expected that the wounds inflicted would be almost evenly distributed over both the upper and the lower parts of the body.

If firing commences when the troops are far apart from each other, the bullets fall at the end of a very long trajectory; and the chances are equal as to their striking any of the parts of the body exposed to them. If the troops are within point blank range, the shot may still be expected to be distributed evenly over the

body, for the aim, under the circumstances in which opposing troops are placed, is always a general one rather than at any particular bodily region.

The more level the surface of the ground on which the opposing troops are placed, the nearer may be expected to be the approach to the average regional distribution named in the preceding chapter; the more broken and uneven, the more that average will be disturbed. Variations in hardness and softness of the ground affect the proportion. When the ground is rocky or frozen, many bullets, on striking it, glance upwards with considerable force. The legs and thighs of soldiers are not unfrequently wounded by projectiles which have rebounded from hard ground or stones, and the number of wounds, which might be expected from an estimate of the superficial area exposed to the direct shots of the enemy in the lower extremities, thus becomes increased. When the ground is soft, as when the troops are marching over ploughed fields, this source of additional wounds is usually avoided.

On the other hand, the lower limbs are not unfrequently protected from the effects of fire, both direct and indirect, by the practice of soldiers to take advantage of any cover they can obtain —in ditches, holes, behind trees, walls, and other obstructions— whenever circumstances admit of their doing so. The higher parts of the body seldom have the advantage of any such cover. The upper extremities are especially exposed in action. They are necessarily left uncovered in carrying and handling the firearms; and are constantly advanced in aiming and firing, as well as in a variety of work requiring manual exertion and dexterity.

Wounds of the hand in warfare.—The disproportionate number of wounds of the hands and fingers has frequently attracted attention in campaigns. One reason given for their frequency on the occasion when the celebrated inquiry by order of the first Napoleon was instituted under the presidency of Baron Larrey, after the battles of Bautzen and Wurschen,[43] was the nature of the ground over which the French troops fought. The infantry charges were chiefly made up the slopes of hills. The soldiers had their hands raised on their firelocks in front of them as they ascended, aiming at the enemy on the summits above, and thus their hands were frequently struck because they were the parts most advanced, and therefore first exposed to be hit. The same effect was said to have been observed on another occasion in the campaign of Poland, where also, from the relatively large number of wounds of the hand, the men were accused of having intentionally mutilated themselves. But there can be no doubt that other shots, besides those of the enemy, have sometimes assisted in increasing the number of wounds of this particular part of the upper extremity. The awkwardness of young soldiers, not well habituated to the use of firearms, has led to accidental wounds in many instances. The fact of rear-rank

men, when troops have been standing in double file, or, as often happened in continental armies, in triple file, incautiously pointing their weapons in the direction of the hands of the front-rank men, has doubtless led to many more such injuries. The nature of the wounds pointed to these accidental causes in some of the instances examined by Baron Larrey, and they were mentioned in his report. During the Italian War of 1859, out of 15,383 wounds by projectiles shown in the hospital returns there were more than one-seventh, viz. 2,300, wounds of the hand and fingers. This large relative number of wounds of the hand is not attributed by Dr. Chenu to the causes which have just been mentioned, but to the nature of the fighting. Dr. Chenu remarks that the sheltered defence of the Austrians in houses, farms, cemeteries, behind walls and entrenchments, necessitated, on the part of the assailants, escalades, manual exertion in breaking open doors, and, in short, a constant use of the hands in a direction toward the enemy, so that they were unavoidably exposed to the action of projectiles more than other parts of the body.

The foregoing observations will prevent surgeons from expecting to find the same proportions of wounds in different regions of the body on all occasions of warfare; and some of them will often serve to explain the discrepancies which may be noticed in these respects in different engagements.

Regional distribution of wounds among soldiers admitted into hospital.— The areal estimates of wounds in different bodily regions shown in the preceding chapter, referring as they do to the total shot exposure, are only to be regarded as data which may be useful for purposes of comparison. They can only be expected to hold good in actual results, on condition that the fighting is in the open field, that all parts of the body are equally exposed to the fire of the enemy, and that the situations of all the wounds inflicted in a given battle have been determined, fatal and non-fatal wounds included. As mentioned elsewhere, however, the only records that are usually kept are those which enumerate the number and nature of the wounds of the men admitted into the hospitals for treatment. The relative proportions of these wounds cannot be expected to agree with the numbers calculated according to the areal exposure of the regions concerned. Many of the wounds inflicted in the regions of the head, neck, and trunk, will have been attended with speedily fatal results; while most of the men wounded in the extremities will have survived to be admitted into the hospitals. The expected percentages of wounds, judging from areal risk, will therefore be greatly disturbed in the former regions; while, as regards the upper and lower extremities, an approach to their calculated relative proportions may be expected to be retained.

Regional distribution of wounds in the French hospitals in 1859. Dr. Chenu has given the following as the approximate regional

percentages of the wounds of 17,000 French soldiers who survived to come under hospital treatment during the Italian war of 1859 :—

Regional Distribution of Wounds	Projectile by which the Wounds were caused		
	Bullet	Cannon Shot	Grape and Shell Fragments
Head	5·6	...	
Face	6·2	...	12·0
Cervical Region . .	1·9	...	
Chest	8·3	...	
Abdomen . . .	6·5	...	41·0
Pelvis	2·9	...	
Scapulo-humeral Region .	7·6	1·1	
Arm	6·5	4·9	
Elbow	·8	·3	21·0
Fore-arm . . .	6·1	2·0	
Hand	19·3	1·1	
Thigh	12·2	40·8	
Knee	2·4	·3	
Leg	10·3	46·7	26·0
Ankle	1·9	2·8	
Foot	1·5		
Total . . .	100·0	100·0	100·0

This furnishes the following regional distribution, when all kinds of projectiles are included in one column, and the regional distribution is confined to the principal divisions to which Dr. Chenu found himself compelled to limit the wounds by grape and shell :—

Wounds of	All projectiles included
Head, Face and Neck	8·56
Trunk	17·56
Upper Extremity	23·56
Lower Extremity	48·30
Total	99·98

The proportionate numbers of wounds, in the great divisions of the body just named, accord more nearly than might have been expected with the measurements of the proportionate areas of the same regions previously given. When brought to a similar standard of one hundred parts, the areas of these regions, according to the ratios given in the preceding chapter, are :—

Head, Face and Neck	8·51
Trunk	28·91
Upper Extremity	21·14
Lower Extremity	41·41
Total	99·97

Regional distribution of wounds in military hospitals in some other wars.—I have calculated the proportions of wounds in these four great divisions of the body in some other wars, the histories of which contain materials, more or less perfect, available for the purpose. In all but two of these instances, not excepting the Crimean War, in which siege operations took so large a part, the wounds of the lower extremities are in excess of those of the upper extremities. The exceptional instances are the war in New Zealand, and the late war on the Gold Coast. In these there was but little fighting in clear open ground. In the New Zealand War the larger number of the wounds were inflicted either by shot discharged from pits like rifle-pits, from stockades and pahs, after the British troops had got into close proximity to them, or in high and dense fern; and all these conditions would necessarily lead to the upper parts of the body being chiefly struck. On inquiring of my friend Sir Anthony Home, V.C., who took an active part in both the wars mentioned, whether his views on the cause of the exceptionally large proportion of wounds of the upper limbs coincided with what I have expressed above, he replied in the affirmative, and added the following remarks:—'In the New Zealand War the wounds were nearly always received at close quarters. The Maoris had no powder to spare, and absolutely not a cap to throw away; they hardly ever fired except the shot appeared certain to take effect. Lying *perdus* either in the trench of their pah or in a hole, they waited until our men were on them—had, in fact, flushed them—and they then fired at the first part of their opponent visible, which would be the head or upper part of the body. Again, our men marched to attack through heavy fern, up to their middles or necks in it, and from this cause the lower half of the body was partly protected, for owing to the Maoris using bad powder and bad projectiles, the fern would occasionally suffice to turn the bullets.'

Very similar conditions existed in the war on the Gold Coast. Nearly all the fighting took place in the midst of tropical bush, in which the troops were able to protect the greater part of their bodies behind trees; while, in aiming and firing at the enemy, the head, neck, and upper extremities would be necessarily exposed to the fire of their adversaries. Moreover, these are the objects which the enemy would principally aim at, from the lower parts of the body being so much concealed. The large proportion of wounds of the head, face, and neck, compared with those of the trunk is unusual, by contrast with the experience of other wars. In the Ashanti War, the wounds of the head were 13·31 per cent. of the total number, of the face 12·23 per cent., neck 5·43 per cent.; or, together, 30·97 per cent. as shown in the table; while those of the chest were only 6·25 per cent., abdomen 4·62 per cent., back and spine 3·53, and perinæum 0·82 per cent.; or, together, wounds of the trunk 15·22 per cent. It will be seen that this is a smaller

Table showing the relative proportions of Gunshot Wounds of the principal bodily regions in certain campaigns and battles.

Campaign or Engagement	Crimea	Crimea, Commissioned Officers	Crimea, Non-Commissioned Officers and Men	Crimea, All ranks combined	New Zealand, All ranks combined	United States. War of the Rebellion 1861–65	Danish War of 1864	Danish War of 1864	Langensalza and Kirchheilingen, 1866	Tauberbischofsheim. 1866	Sedan, 1870	Metz, 1870	Ashanti War, 1873–74	All the foregoing campaigns and battles
Nation	French	British	British	British	British	Unionists	Prussians	Danes	Prussians and Hanoverians	Prussians and South Germans	French	Germans	British	Various
Number of Wounds specified	33,218	544	6984	7525	463	82,415 (Numbers incomplete)	1968	1203	1092	297	579	875	368	130,003
Authority for the figures on which the proportions are calculated	Chenu	Official History	Official History	Official History	Army Medical Reports, vol. vii. 1867	Circular No. 6 1865	Loeffler	Loeffler	Stromeyer	Beck	MacCormac	Fischer	Official Despatches	Various
Head, Face, and Neck	166·7	195·6	216·5	215·0	144·7	128·0	158·5	121·3	106·2	97·6	91·5	121·1	309·7	150·9
Trunk	164·9	221·4	148·3	153·6	198·7	197·0	168·7	234·4	167·6	161·9	214·2	187·4	152·2	182·2
Upper Extremities	315·0	202·9	306·1	298·6	343·4	310·9	308·9	263·5	273·8	202·0	253·9	284·6	304·4	287·2
Lower Extremities	353·4	380·1	329·1	332·8	313·2	364·1	363·8	380·7	452·4	535·3	440·4	406·8	233·7	379·7
Total	1000·0	1000·0	1000·0	1000·0	1000·0	1000·0	999·9	999·9	1000·0	999·8	1000·0	999·9	1000·0	1000·0

percentage of wounds of the trunk, as compared with those of the head, face, and neck, than is shown in any other war; and the peculiar circumstances, already mentioned, under which the fighting took place, serve to explain the difference. The wounds of the upper extremities are considerably in excess over those of the lower extremities, even more so than they were in the war in New Zealand. It is probable that in most wars of a similar kind, wars in which bush-fighting predominates, a similar departure from the usual relative proportions of wounds of the upper and lower extremities will be met with.

The table on the preceding page exhibits the calculations to which I have just referred. The general average is shown in the last column. If those wars in which the fighting chiefly took place in the open field be regarded separately, and the observations are confined to the experience which has been gained in civilised warfare during recent years, viz., that shown in the tables referring to the wars of 1864, 1866, and 1870, and to the incomplete, but probably fairly illustrative, figures quoted regarding the war of the rebellion in the United States, then the average will be as follows:—

Head, Face and Neck	117·8
Trunk	190·6
Upper Extremities	271·1
Lower Extremities	420·5

Average regional distribution of wounds among hospital patients in time of war.—Accepting, therefore, the average percentage of deaths on the field to wounds inflicted, shown at page 591, as a basis, it may be assumed, that, in every 1,000 casualties in warfare, there will be about 200 deaths on the field; and that, of the remaining 800, using the proportions mentioned in the preceding paragraph, there will be admitted into hospital, in European warfare, about 94 wounds of the head, face, and neck; 153 of the chest, abdomen, and pelvis; 217 of the upper extremities; and 336 of the lower extremities.

CHAPTER VI.

RELATIVE FATALITY OF GUNSHOT WOUNDS IN DIFFERENT BODILY REGIONS.

General causes which affect the ratios of mortality in gunshot injuries.—It is not the purpose of the remarks in this chapter to estimate the ratios of mortality in wounded men according to the effects produced by different kinds of projectiles, but rather to observe how far certain ratios of mortality are preserved in wounds of different regions of the body, when the firearms and projectiles by

which the wounds are caused, and the circumstances under which they are inflicted, are apparently alike. Even under these conditions, there will be variations in the absolute mortality from wounds of corresponding kinds, as well as variations in the relative mortality of wounds in the separate regions. The nature of the engagement, whether it is one on a large scale or one of minor importance; the plan on which the surgical arrangements are conducted, whether it is one by which early assistance can be given to the wounded, or one under which such help is delayed, or, in other words, the length of time the wounded are left on the field unattended to; the distance which has to be traversed before the field-hospitals are reached; the nature of the ground and of the means of transport; the kind of hospital employed, whether tents, huts, or buildings, and, in the latter case, their form and position; the number of the wounded collected in the separate hospitals; the quality and amount of surgical attention and nursing help; the state of general health of the troops as influenced by length of service in the field, circumstances in respect to diet, exposure, season, climate, temperature, and other conditions which I may have omitted to mention; all these matters exert an influence on the ratios of mortality from gunshot wounds shown in statistical returns, irrespective of differences in the wounds themselves. Some of them influence the absolute amount of mortality among the wounded, others more affect the apparent mortality. Some illustrations of each of these results may be given.

Effects of increase in dimensions of battles.—The absolute mortality among the wounded is always increased in vast battles like those of Königgrätz, Solferino, Gravelotte, and others. The wounded are so numerous, and fall within such comparatively short periods of time, that it becomes physically impossible, with the usual amount of hospital and sick-transport staff available, to afford the necessary surgical assistance, or to carry the wounded away to places where it can be obtained. Under such circumstances many men die from simple want of attention. It is, indeed, a matter of old remark that the percentage of mortality among men wounded in battle increases as their number is increased. It is obvious that this must arise from the fact that, in small engagements all the wounded can receive the necessary attention quickly, but in large battles adequate surgical care and attention can hardly be given to any; while a large number of the wounded must remain without any attention at all, or, at least, cannot receive it until too long a time has elapsed for it to be of much avail. The late Surgeon-General Dr. Loeffler, of the Prussian army, basing his observations on experience gained in the slighter engagements and larger battles during the war between Prussia and Austria, in 1866, has proved that in almost every instance the mortality among the wounded of that campaign was increased concurrently with an in-

crease in their numbers. The following is Loeffler's table[44] showing the number of wounded in certain engagements, and the percentages of mortality among them.

Number of Wounded	Mortality among them
54	3·7 per cent.
134	7·2 „
163	6·7 „
2,196	10·5 „
7,404	11·5 „

Increased ratio of mortality from aggregation of wounded.—The increased mortality from wounds, when large numbers of wounded soldiers are massed together for treatment, in consequence of the destructive diseases generated and disseminated by aggregation, is now fully recognised. The steps taken to prevent accumulations of wounded for combined treatment in large buildings have constituted one of the greatest improvements which have been effected of late years in military medical administration. Nothing has more tended to diminish the preventible mortality among wounded men, than the plan adopted of treating them in freely aërated huts or tents; at the same time, limiting the numbers collected in one place, as far as economical and transport considerations will admit. Circumstances still occur in warfare, however, under which a large accumulation of wounded, at least for some time, is unavoidable; and whenever this does happen, an increase in the absolute mortality among them is always observed to be the result, whatever pains may be taken to obviate it.

Apparent increase in ratios of mortality in certain wounds.—The following fact serves to illustrate the difference which there may appear to be in the relative fatality of certain wounds under hospital treatment, owing to differences in the distances of the hospitals from the places of fighting. During the Crimean War the percentage of fatality of chest wounds, all kinds of chest wounds being taken together, in the French military hospitals was 30·7 per cent. This ratio of mortality was almost the same as it was in the hospitals of the British army. In the French hospitals during the Italian campaign of 1859, however, the mortality was only 18·9 per cent. The altered rate of mortality shown in the hospital returns of the latter war cannot be said to have been due to any diversity in the nature of the wounds inflicted in the field, nor in that of the treatment adopted in the hospitals; it was obviously attributable to the fact that the field-hospitals in the Crimea were close to the places where the wounds were received, while in the Italian War they were situated for the most part at a considerable distance from them. In the Crimea, the patients were received into the ambulances shortly after their wounds had been inflicted; in Italy, owing to the largeness of the number of

wounded resulting from the principal battles, and the consequent difficulties of transport, together with the distance of the hospitals, many of the severer cases did not live long enough to be admitted into hospital for treatment,—they died on the field of action itself. The chest wounds among the 'killed in action' in Italy were increased in number; the deaths among those treated in hospital were, in proportion, lessened in number. The absolute mortality from wounds of the chest was probably very similar in both the Italian and Crimean wars.

Ratios of mortality in abdominal wounds.—The wounds most immediately fatal in the field are wounds of the head and chest. Penetrating wounds of the abdomen, even with visceral complications, are not so quickly fatal as a very large proportion of penetrating wounds of the head and chest. A considerable number of penetrating wounds of the abdomen usually prove fatal, however, within 12 hours, or, at most, within 24 hours after their infliction. When, therefore, we find a large proportion of wounds of the abdomen among the dead on a field of battle and few in the hospitals, we may infer that there has been delay from some cause or other in removing the wounded; when we find a large ratio of mortality among wounds of the abdomen in the field-hospitals, we may equally infer that the wounded have been removed to them without much delay. In the Crimean War the percentage of mortality in wounds of the abdomen among the British officers treated in the field-hospitals was the highest of any regional wounds, viz., 51·5 per cent., and of the non-commissioned officers and men equally the highest of any regional wounds among them, viz., 55·7 per cent. This fact alone shows that no long time elapsed before the wounded officers and men referred to were placed under hospital care. In the French hospitals in the Crimea, also, wounds of the abdomen gave rise to a higher percentage of mortality than any other regional wounds, viz., 42·62 per cent.; while in the French hospitals in the Italian War the mortality among them was only 26·64 per cent. These facts point to early removal to hospitals in the one instance, comparatively late removal in the other.

Ratios of mortality according to the situation of hospitals.—It has often been noticed that the wounds of those who are treated in the villages and towns nearest to battle-fields, are followed by a larger ratio of mortality than those of the wounded treated in distant hospitals. There are several reasons why these different results may be expected to occur. In the first place, the most gravely wounded, those who are the most unfit to be removed to distant hospitals,—in many instances soldiers whose wounds are inevitably mortal—are retained in the nearest field-hospitals; in the second place, the hospital arrangements in these situations are usually the most makeshift in character, the surgical appliances the most defective, and the hygienic conditions, within the hospitals and

around them, not unfrequently very inferior. Those of the wounded, therefore, the issue of whose wounds may be regarded as the most doubtful, are placed in circumstances nearly all of which are unfavourable to their recovery. Opposite conditions usually exist in the hospitals placed at a distance from the scene of action. To these the slightly wounded are usually sent, and those who have partly recovered from their injuries, or from the surgical operations consequent on them, in short, all those who are more likely to undergo the fatigues and exposure of the transport with impunity; while the hospitals in such situations, being for the most part fixed establishments, are generally provided with all the necessary material means for the best treatment of their inmates, and, at the same time, have a more complete professional and nursing staff. The statistics of wounds, and of the results of their treatment, in different places, will often be calculated to deceive, unless these facts are borne in mind.

Regional fatality of wounds on the field of action itself.—There are very few data on which to base calculations of the relative mortality of wounds of different regions on the field of battle itself. The pressure on the time of surgeons in attending to the living wounded rarely permits the opportunity of examining the nature, or even the mere situation, of the wounds of those who have been killed outright. It could not possibly be done on the occurrence of large battles under the ordinary conditions of warfare. The observation has been made to a partial extent on several occasions. During the New Zealand War of 1863–65, the region of the body wounded in 118 men who were killed on the scene of action itself was noted, and is recorded in the official report of the war.[45] The following table shows the number of wounds in each region on this occasion, and the percentages of their occurrence.

Region	Killed on the spot	Percentage
Chest	59	50·00
Head	40	33·90
Abdomen	11	9·32
Neck	4	3·39
Thigh	4	3·39
Total	118	100·00

Regional fatality of wounds within forty-eight hours.—Dr. Loeffler, in his account of the Danish War of 1864, has recorded the regional distribution of the wounds of 387 Prussians who were killed directly on the field of action, (33 killed, the situations of whose wounds were not noted, being excluded), as well as of 82 others who died during the first 48 hours from their injuries.[46] On

calculating the percentages derived from these figures, the order of mortality of the regional wounds is found to differ, as appears in the adjoining table, only in a small degree from that in the one preceding.

Region	Killed on the spot	Died within 48 hours	Total killed and died	Percentage of killed on the spot	Percentage of dead in first 48 hours
Chest . . .	196	13	209	50·65	44·56
Head . . .	117	20	137	30·23	29·21
Abdomen and Pelvis	44	34	78	11·37	16·63
Lower Extremities .	13	7	20	3·35	4·27
Neck . . .	8	3	11	2·07	2·35
Back . . .	7	3	10	1·81	2·13
Upper Extremities .	2	2	4	0·51	0·85
Total . .	387	82	469	99·99	100·00

It will be seen by these figures, that the order of fatality according to regions is not very materially changed, by adding those who succumbed during the first 48 hours, from what it is among those who were killed on the field itself. The numbers of deaths differ considerably on separating the two categories, as might be expected; but the order of regional fatality in those who were killed on the spot is but little altered by the addition of those who may be regarded as having been in a dying state at the time they were removed from the field to the field-hospitals.

Regional fatality of wounds among patients in military hospitals. It will be readily understood that when those who are killed on the field itself, or who die within a few hours after an action, are excluded (and the returns of 'killed in action' often include those who die within 24 hours, and sometimes those who sink during the second day, if not later), the regional order of fatality among the gunshot wounds which remain will necessarily become materially changed. The severe wounds of those regions, the wounds of which are usually attended with the most speedily fatal results, have in a great number disappeared from the hospital lists, and the less serious wounds among them only remain for treatment.

There are so many sources of fallacy when the percentages of mortality are derived from the partial admissions of cases and the results of their treatment in particular hospitals (some of the causes of which have been already explained), that I have preferred to select a few examples in which the number of wounded occurring and treated throughout a whole war, or those resulting from an entire battle, could be obtained, and the total number of deaths resulting among them shown. As these figures must include the results of treatment both in the near and distant hospitals, and under all conditions, a closer approximation to the truth may be hoped to be arrived at than could be by selecting disjointed results. The only exception I have introduced has been the partial experience gained

in the hospitals at Sedan and Balan by Mr. MacCormac and Dr. Frank. As this experience was gained in hospitals on the field of action itself, to which the wounded were brought indiscriminately from the conflict, and where circumstances allowed the wounded to be retained for a considerable time, the results may, perhaps, be fairly taken as a sample of what would have been the experience if the whole of the results of the great and decisive battle of Sedan could have been gathered together and completed.

The campaigns or battles, respecting which sufficient information has been found to exist for basing the calculations just mentioned upon, are the following: Crimean and Italian Wars, French; Crimean War, British; New Zealand War, British; war of 1864, Prussians and Danes; Ashanti War, British; and the campaign between Prussia and Hanover in 1866. Calculations, founded on Mr. MacCormac's observations at Sedan, have also been added, as already mentioned.

Regional fatality of wounds among French soldiers during the Crimean War.—The following tables show the order of fatality of the gunshot wounds, and the surgical operations necessitated by them, among the cases treated in the ambulances and hospitals of the French army during the Crimean War, and the subsequent Italian Campaign of 1859.[47] Owing to the manner in which the wounds are classified in Dr. Chenu's very valuable histories of these wars, the regions cannot be arranged, or the percentages calculated, in exactly the same manner as they are in the British tables. Wounds penetrating the articulations, for example, are not separated from those affecting the parts surrounding the articulations. Other differences in details of classification exist, which interfere with exact comparison between the French and other returns.

Crimean War, 1854-56. French					Italian Campaign, 1859. French				
Order of Fatality	Region	Number Wounded	Number Died	Percentage of Mortality	Order of Fatality	Region	Number Wounded	Number Died	Percentage of Mortality
1	Abdomen[48] . .	610	260	42·62	1	Back, Sacrolumbar, Iliac and Glutæal . . .	361	122	33·80
2	Lower Extremities[49]. . .	11,415	428[illegible]	37·6	2	Abdomen . .	1013	263	[illegible]
3	Neck . . .	4[illegible]5	146	33·6	3	Neck . . .	203	43	21·18
4	Perinæum and Genito-urinary Organs . .	231	77	[illegible]	4	Head . . .	779	156	20·0[illegible]
5	Chest . . .	2606	817	31·35	5	Chest . . .	1052	199	18·92
6	Back, Sacrolumbar, Iliac and Glutæal . . .	1947	616	31·64	6	Perinæum and Genito-Urinary Organs . .	106	20	18·86
7	Head . . .	2711	761	28·0	7	Lower Extremities . . .	7704	1337	17·35
8	Upper Extremities	88[illegible]3	2115	24·0	8	Face . . .	955	114	11·94
9	Face . . .	2[illegible]92	414	18·5	9	Upper Extremities	6721	[illegible]	9·[illegible]
	Total . .	31,151	9525	30·57		Total . .	18,894	291[illegible]	15·41

Regional fatality of wounds in the British army during the Crimean War.—The next table shows the order of fatality of the gunshot wounds according to regions, firstly among the officers, and secondly among the non-commissioned officers and privates, treated in the British hospitals during the Crimean War. The wounds of the former are quoted for the whole of the war, the latter from April the 1st, 1855, to the end of the war, as the most reliable period.[50]

Crimean War, 1854–55. *British.*

Officers					Non-Commissioned Officers and Privates				
Order of Fatality	Region	Number Treated	Number Died	Percentage of Mortality	Order of Fatality	Region	Number Treated	Number Died	Percentage of Mortality
1	Abdomen	33	17	51·5	1	Abdomen	235	131	55·7
2	Chest	54	17	31·5	2	Perinæum and Genito-Urinary Organs	55	17	30·9
3	Joints	10	3	30·0	3	Chest	420	118	28·1
4	Head	47	8	17·0	4	Joints	121	25	20·7
5	Neck	19	2	10·5	5	Head	851	170	20·0
6	Back and Spine	29	3	10·3	6	Back and Spine	326	45	13·8
7	Lower Extremity	200	10	5·0	7	Lower Extremities	2215	174	7·8
8	Upper Extremity	108	4	3·7	8	Neck	128	4	3·1
9	Perinæum and Genito-Urinary Organs	4	0	0·0	9	Face	533	14	2·6
10	Face	40	0	0·0	10	Upper Extremity	2100	55	2·6
	Total	544	64	11·76		Total	6984	753	10·78

Regional fatality of wounds in the last New Zealand War.—The order of fatality among the gunshot wounds and injuries received during the war in New Zealand from May 1863 to June 1865 is next shown.[51] It includes the wounds among officers, non-commissioned officers, and privates.

New Zealand War. British Officers, Non-Commissioned Officers and Men.

Order of Fatality	Region	Number of Wounds	Deaths	Percentage of Mortality
1	Blood-vessels	2	2	100·00
2	Abdomen	23	14	60·87
3	Chest	38	14	36·84
4	Head	36	11	30·55
5	Back and Spine	25	6	24·00
6	Joints	33	5	15·15
7	Face	21	1	4·76
8	Lower Extremities	133	6	4·51
9	Upper Extremities	132	0	0·0
10	Perinæum, and Genito-Urinary Organs	5	0	0·0
11	Neck	10	0	0·0
12	Nerves	5	0	0·0
	Total	463	59	12·96

Regional fatality of wounds after the battle of Waterloo.—Sir Charles Bell has left a manuscript note in an interleaved book which he used at Brussels, and in which he recorded some memoranda which were principally based on his observations in the hospitals he visited after the battle of Waterloo,[52] to the effect that the following is the order of importance of the regions of the body as regards gunshot wounds: 1. abdomen; 2. chest; 3, head; 4, joints; 5, large bones. The volume in which this annotation occurs is preserved at Netley. The correctness of Sir C. Bell's arrangement appears to have been very closely confirmed by the experience of the Crimean and New Zealand Wars, shown in the foregoing tables.

Regional fatality of wounds in the wars of 1864 and on other occasions.—The mortality of gunshot wounds according to bodily regions in the Prusso-Danish War of 1864, has been deduced from the numbers given in the returns published by Dr. Loeffler.[53] The wounded among the Danes, shown in the second half of the table, are those who were treated in the Prussian hospitals, and as it may well be supposed that most of the Danish wounded, the nature of whose wounds did not prevent them from doing so, effected their escape, they may be regarded as having consisted of the men whose cases presented the most severe characters. This will probably explain the higher ratios of mortality which appear among the regional injuries on the Danish side of the table, as compared with those on the previous section of it which refer to the Prussian wounded.

Prusso-Danish War of 1864.

Prussians					Danes				
Order of Fatality	Region	Number Wounded	Number Died	Percentage of Mortality	Order of Fatality	Region	Number Wounded	Number Died	Percentage of Mortality
1	Bloodvessels .	3	3	100·00	1	Chest . . .	113	76	67·25
2	Abdomen . .	103	59	57·28	2	Abdomen . .	89	57	64·04
3	Chest . . .	137	57	41·60	3	Joints . . .	57	28	49·50
4	Joints . . .	43	17	39·50	4	Back and Spine .	80	32	40·00
5	Back and Spine, and Glutaal Region . . .	92	27	29·34	5	Bloodvessels . .	6	2	33·33
6	Head . . .	161	21	14·9	6	Lower Extremities	458	146	31·87
7	Lower Extremities	716	90	12·57	7	Head . . .	61	19	31·1
8	Neck . . .	10	1	10·00	8	Upper Extremities	252	32	12·7
9	Upper Extremities	555	33	5·9	9	Neck . . .	26	2	7·69
10	Face . . .	111	1	0·9	10	Face . . .	59	3	5·1
11	Nerves . . .	7	0	0·0	11	Nerves . . .	2	0	0·0
	Total . .	1968	315	16·00		Total . .	1203	397	33·00

The ratio of mortality among the regional wounds treated

during the short campaign between Prussia and Hanover in 1866, are as follows:—

Langensalza and Kirchheiligen.

Order of Fatality	Region	Number Treated	Number Died	Percentage of Mortality
1	Spine	8	6	75·00
2	Chest	102	32	31·37
3	Joints	95	29	30·52
4	Abdomen	70	21	30·00
5	Head	46	10	21·74
6	Lower Extremities	433	48	11·85
7	Neck	18	2	11·11
8	Upper Extremities[51]	264	20	7·57
9	Face	51	2	3·92
10	Perinæum and Genito-Urinary Organs	5	0	0·00
	Total	1092	170	16·48

The number of wounded soldiers treated after the battle of Sedan, and the resulting deaths among them recorded by Mr. MacCormac, give the following ratios according to the several regions of the body injured:—

Sedan,

(MacCormac.)

Order of Fatality	Region	Number Wounded	Number Died	Percentage of Mortality
1	Abdomen	12	8	66·6
2	Head	17	9	52·9
3	Joints	44	23	52·2
4	Chest	54	19	35·2
5	Back and Spine	24	8	33·3
6	Lower Extremities	264	54	20·4
7	Face	29	5	17·3
8	Upper Extremities	130	11	8·5
9	Neck	5	0	0·0
10	Various (not specified)	31	0	0·0
	Total	610	137	22·45

General results of the foregoing observations.—On adding together the mortality results in the tables which can be most safely combined in regard to correspondence in classification, viz:—those of the Crimean, New Zealand, and Italian Wars, the Prusso-Danish War of 1864, the Hanoverian campaign of 1866, and MacCormac's experience at Sedan, the general result is as follows:—

	Crimean War. British Officers	Crimea. British N. C. Officers and Privates	New Zealand. British	Crimea. French	Italian War. French	1864. Prussians	1864. Danes	1866. Germans	1871. Sedan	Total Average from the mean of the ratios
Abdomen	51·5	55·7	60·87	42·62	25·96	57·28	64·04	30·0	66·6	50·51
Chest	31·5	28·1	36·84	31·35	18·92	41·60	67·25	31·37	35·2	35·79
Head	17·0	20·0	30·55	28·0	20·03	14·9	31·1	21·74	52·9	26·24
Neck	10·5	3·1	0·0	33·6	21·18	10·0	7·69	11·11	0·0	10·80
Back and Spine	10·3	13·8	24·0	31·64	33·80	29·34	40·0	75·0	33·3	32·36
Lower Extremity	6·3	8·23	7·64	57·6	17·35	12·57	31·87	14·26	23·7	17·72
Upper Extremity	3·6	3·1	0·67	24·0	9·80	8·3	19·4	9·03	13·1	10·11
Perineum	0·0	30·9	0·0	32·9	18·86	0·0	0·0	0·0	0·0	13·78
Face	0·0	2·6	4·76	18·5	11·94	0·9	5·1	3·92	17·3	7·24

Professor De Chaumont, of the Army Medical School, has calculated for me the corrected mean of the foregoing averages of mortality in wounds of different regions. The following table shows side by side the averages obtained from the total number of cases and deaths in each regional series, while the last column exhibits the corrected results according to Dr. De Chaumont's calculation. The terminal figures may be accepted as the most reliable.

Summary of the Percentages of Deaths to Wounded treated, according to Regions.

Regions	Cases	Deaths	Averages obtained from the Total Numbers	Averages obtained from the ratios of each group	Mean of the above Averages	Corrected Mean
Abdomen	2188	830	37·935	50·508	44·221	43·825
Chest	4576	1349	29·480	35·792	32·636	31·932
Back and Spine	2892	865	29·910	32·364	31·132	29·514
Perinæum	409	114	27·873	13·777	20·825	21·696
Head	4709	1168	24·803	26·244	25·523	24·101
Lower Extremities	23,704	6212	25·819	17·724	21·771	22·033
Neck	884	203	22·964	10·798	16·881	13·632
Upper Extremities	19,312	3002	15·545	10·112	12·828	12·975
Face	4191	584	13·935	7·244	10·589	10·547

Successive rates of mortality in wounds under hospital treatment according to duration of time.—The following table though not complete, owing to the dates of death after those of the receipt of the wounds not being known in a certain number of cases, is still of interest, as it shows the rate of progression of mortality in a large proportion of the injuries which terminated fatally in the British hospitals during the Crimean War.

Table showing the duration of some of the Wounds and Injuries under hospital treatment which proved fatal among the regiments of the British Army during the Crimean War.[56]

Duration under Treatment	Number of Deaths
Under 1 day	160
1 day, but under 2 days	149
2 days " 3 "	91
3 " " 4 "	66
4 " " 5 "	47
5 " " 6 "	51
6 " " 7 "	44
7 " " 8 "	30
8 " " 2 weeks	167
2 weeks " 3 "	93
3 " " 4 "	45
4 " " 5 "	49
5 " " 6 "	21
6 " and over 6 "	59
Period unknown	409
Total	1,481

Progressive decrease of wounded patients under hospital treatment from recoveries and deaths.—The large preponderance of deaths which occurred in the first week, when contrasted with those in subsequent weeks, is very noticeable. Thus of 1,013 wounded patients, in whose cases the date of fatal termination was noted during the first six weeks, there died in the first week, 638; in the second, 167; in the third, 93; in the fourth, 45; in the fifth, 49; in the sixth, 21. When this progressive rate of decrease from death is added to that from the returns to duty among wounded patients, an idea can be formed of the amount of hospital accommodation which will probably become vacant from these two sources in certain periods of time.

The following table, derived from the surgical history of the Crimean War,[57] supplies this information, in respect to 4,015 men who returned to duty out of a number of 6,359 wounded men treated.

Duration of Treatment	Returned to duty	Ratio per cent. returned to duty
Under 1 week	1476	23·2
Over 1 " but under 1 month .	1408	22·1
Over 1 month " 2 months .	709	11·1
Over 2 months " 3 " .	263	4·1
Over 3 " " 4 " .	101	1·6
Over 4 " " 5 " .	40	0·6
Over 5 " " 6 " .	11	0·1
Over 6 "	7	0·1
Total returned to duty . .	4015	63·1

CHAPTER VII.

PROPORTIONS OF SLIGHT TO SEVERE WOUNDS IN BATTLE.

In the appendix to my work on Ambulance Transport, before referred to, some tables were inserted showing the ratios of comparatively slight to severe wounds so far as the experience gained in certain wars afforded information on the subject. Their purpose was to form the basis of an estimate for determining the amount of transport which should be supplied at the commencement of a campaign for the removal of wounded men in a sitting posture, and the amount required to admit of patients being carried recumbent. The tabulated wounds of the Crimean and New Zealand Wars, and also of the War of the Rebellion in the United States, so far as information regarding it was available, were separated into two groups,—one consisting of such wounds as might be supposed not to prevent the subjects of them from maintaining a sitting position, the other of those usually found to necessitate the removal of the patients lying down. As these ratios are useful for reference, I insert them here, with the addition of a column derived from Surgeon-General Stromeyer's returns of the Prusso-Hanoverian conflict of 1866. I have not met with any other numerical returns for entire campaigns capable of being arranged under the same headings as those of the Crimean and New Zealand Wars.

Slighter Wounds, the subjects of which might be transported sitting.

Description of Wound.	Crimea, N. C. Officers and Men	Crimea, Commissioned Officers	New Zealand, N. C. Officers and Men	New Zealand, Officers, N. C. Officers and Men	United States	Prusso-Hanover, 1866
Wounds of head without depression or penetration of bone . .	691	40	23	25	3912	29
Flesh wounds of face, and wounds with slighter forms of injuries to bones of face	382	33	13	14	2588	26
Flesh wounds of neck	128	19	8	10	1329	16
Wounds of chest (non-penetrating)	255	25	9	12	4759	49
Wounds of abdomen (non-penetrating)	101	14	8	8	2181	7
Flesh wounds of back	299	21	17	19	5195	0
Wounds of upper extremities .	2083	106	145	156	25,620	299
Wounds of lower extremities (flesh wounds)	792	66	56	61	12,576	317
Total	4731	327	279	305	58,190	743

Severer Wounds, the subjects of which mostly require to be transported lying down.

Description of Wounds	Crimea. N. C. Officers and Men	Crimea. Commissioned Officers	New Zealand. N. C. Officers and Men	New Zealand. Officers, N. C. Officers and Men	United States	Prusso-Hanover. 1866
Wounds of head, with depression or penetration of bone . . .	160	7	9	11	1108	17
Wounds of face, implicating bones	151	7	6	7	1579	25
Wounds of chest, penetrating or injuring bones	165	29	22	26	2183	55
Wounds of abdomen, penetrating .	134	19	10	15	962	12
Wounds of perinæum, &c. . .	55	4	5	5	468	55
Wounds of back, with injury to spine	27	5	5	6	187	8
Wounds of lower extremities, with or without fractured bones .	1406	134	73	79	17,438	133
Wounds of nerves, vessels, and joints	155	12	6	9	—	44
Total	2253	217	136	158	24,225	349

Table showing the Ratios of (A) Slighter Wounds, the subjects of which might be transported sitting, to (B) Severer Wounds, the subjects of which mostly require to be transported lying down.

Description of Wounds	Crimea. N. C. Officers and Men	Crimea. Commissioned Officers	New Zealand. N. C. Officers and Men	New Zealand. Officers, N. C. Officers and Men	United States	Prusso-Hanover. 1866
(A) Wounded patients for sitting position	4731	327	279	305	58,190	743
(B) Wounded patients for recumbent position	2253	217	136	158	24,225	349
Total wounds specified .	6984	544	415	463	82,415	1092
Percentage of (A) patients sitting .	67·9	60	67·2	65·9	70·6	68·0
Percentage of (B) patients recumbent	32·1	40	32·8	34·1	29·4	32·0

Ratios of slight to severe injuries in the Crimean and Italian wars in the French army.—Although the classification, adopted by Dr. Chenu in his valuable surgical histories of the Crimean and Italian Wars, prevent the injuries tabulated by him from being arranged in exact accord with the plan adopted in the foregoing tables; an approximate estimate of the proportion of slight to severe wounds may, perhaps, be arrived at by classing those which are shown to have become healed without having caused the patients

to quit the service, as comparatively slight wounds, and those necessitating retirement from the army or leading to death, as severe wounds. It is hardly probable that any very severe injuries to nerves, bones, cavities, or viscera, could have occurred without having resulted either in the death, pensioning, or retirement from the army of the patients concerned. The inference is, therefore, that those wounds which have not been included under either of these headings, but simply under the heading of 'healed,' were comparatively slight injuries.

It is on this principle that the distinction has been made in the following tables. The numbers under 'slight' are those which are recorded as 'guéris' by Dr. Chenu: the numbers under 'severe' are those which are recorded by him under the headings of 'Retraités,' 'Pensionnés temporairement,' and 'Morts.'[58] It will be seen that, even under this different mode of proceeding, the percentages of the total numbers approximate very closely to those shown in the previous tables.

Crimean Campaign. French Army.

Regions of Wounds	Total	Slight	Severe	Percentages Slight	Percentages Severe
Head	2711	1827	884	67·4	32·6
Face	2372	1494	878	62·9	37·1
Neck	435	272	163	62·5	37·5
Chest	2657	1735	922	65·3	35·7
Back	1950	1262	688	64·7	35·3
Abdomen	550	338	212	61·48	38·5
Perineum	381	210	171	54·16	45·9
Upper Extremities	9466	6295	3171	66·5	33·5
Lower Extremities	11,743	5871	5872	50·0	50·0
Total	32,265	22,475	9790	69·66	30·34

Italian Campaign, 1859. French Army.

Regions of Wounds	Total	Slight	Severe	Percentages Slight	Percentages Severe
Head	779	566	213	72·7	27·3
Face	955	607	348	63·6	36·4
Neck	203	139	64	68·5	31·5
Chest	1052	663	389	63·1	36·9
Abdomen	917	642	275	70·1	29·9
Back	361	103	258	28·7	71·3
Perinæum	202	118	84	58·5	41·5
Upper Extremities	6721	4339	2382	64·6	35·4
Lower Extremities	7704	5144	2560	66·8	33·2
Wounds not determined	778	729	49	93·7	6·3
Total	19,672	13,050	6622	66·33	33·67

Ratios of slight to severe wounds in the war of 1870–71.—One of the tables (Table A) in Fischer's statistics of the losses in the Prussian and North German armies during the war of 1870–71, indicates the proportions of severe and slight wounds, but the figures contain many elements of uncertainty. It will be observed that no information is afforded respecting more than 30 per cent. of the total number. This large proportionate number of wounds, about which detailed particulars are wanting, also lessens the value of Fischer's statistics of the Franco-German War for other purposes of comparison. The summary of Fischer's table is as follows:—

Nature of Injury	Number Injured	Percentage of Injuries
Killed	7735	8·7
Slight wounds	30,379	34·0
Severe wounds	23,054	26·0
Wounds without indication whether they were slight or severe . .	3729	4·3
Wounds, nature not specified . .	23,717	26·7
Accidental injuries, not gunshot . .	263	0·3
Total	88,877	100·0

General conclusion on the subject.—It may be roughly estimated, from the most reliable of the foregoing observations, that, excluding those injuries which prove directly fatal on the field of action itself, one-third of the remainder may be classified as severe, and two-thirds as slight injuries.

CHAPTER VIII.

ACCIDENTAL GUNSHOT INJURIES IN WAR TIME.

The gunshot injuries which occur in time of war are not all produced by the fire of the enemy. Some are accidental, and the number of these is often far greater than might be anticipated. Inadvertence, and the premature discharge of firearms in the hands of soldiers, the unintended discharge of firearms in the hands of comrades, the accidental ignition of cartridges or explosions of shells, powder cases, and magazines, are the common sources of these injuries. During the Crimean War many officers armed themselves with revolver pistols, and the wounds caused accidentally by these weapons among those who carried them were by no means few in number, and sometimes led to very serious results.

Accidental gunshot wounds in the New Zealand war.—Accidental wounds are rarely distinguished in the numerical returns of armies from those which result from the fire of the enemy. The distinction is, however, noted in the surgical report of the New Zealand War of 1863-65.[59] The recorded number of gunshot wounds among the men in this war was 415, and of this number 28 were accidental, or nearly 7 per cent. Of these 28 accidental injuries, 10 took place in the Wanganui campaign, where the number of wounds inflicted by the enemy was only 68; so that one-seventh part of the gunshot wounds were accidental on this occasion. Six of the 10 were self-inflicted wounds of the hand, but there was no ground for suspecting them to have been done designedly.

Accidental injuries of various kinds in campaigning.—When accidental surgical injuries of all kinds occurring in the course of a campaign are taken together, such as contusions and strains during the manipulation of heavy guns as well as in the use of smaller firearms, together with the different kinds of injuries which result from the very varied occupations in which troops have to employ themselves while on active service before an enemy, the number usually appears to be very large. As these injuries generally result from the military operations in progress, they are, as a rule, mixed in the hospital returns with all the other injuries resulting from the war in which the troops are engaged. It is not always possible to eliminate them from those which are inflicted by the enemy. They sometimes, however, swell the figures in the numerical returns to so large an extent, that they ought to be excluded from the statistics of the injuries really inflicted in action. Thus the number of injuries treated in the British hospitals during the Crimean War was 18,283. But of this number, 6,768, or considerably more than one-third, were accidental injuries not occurring in action;[60] so that the number of those which were actually received in battle becomes reduced to 11,515.

There is no reason for supposing that the proportion of accidental wounds and injuries in this instance was greater than usually happens with armies in the field. So large a number sufficiently indicates the need of separating accidental wounds, whenever it is practicable to do so, from those received in action with an enemy. The injuries included in Dr. Chenu's tables of the Crimean and Italian Wars, under the heading of 'Causes Diverses,' were probably chiefly composed of accidental injuries of the classes above mentioned, and a portion of the other injuries which are included in the column of gun-shot wounds probably had a similar origin. The number of accidental wounds cannot, however, be determined, as no special information is given on the subject.

CHAPTER IX.

ULTIMATE RESULTS OF GUNSHOT WOUNDS RECEIVED IN WARFARE.

The final results of gunshot injuries, excluding those which have proved fatal on the field of action, are shown in military returns under the following categories: 1. *Discharged to duty*; 2. *Invalided, or discharged from military service*; and 3. *Died under treatment*. The state of those who are invalided is left undefined in the numerical returns; it is only shown in the reports, or special tables, on the regional classes of wounds to which the injuries of the men invalided have happened to belong.

Statistics of the numbers of wounded men who recover and return to duty in different wars become important, so far as they afford an indication of the probable restoration from this source of the strength of a combatant force, when it has been lessened by the effects of injuries resulting from action with an enemy; the statistics of the numbers invalided become important, so far as they show the probable number of invalids who may be expected to require support from the country, and of men who will return disabled to the civil population from which they were originally drawn as able-bodied recruits.

Exact statistics of the ultimate results of gunshot injuries not readily obtainable.—It might well be supposed that no difficulty would be met with in obtaining the necessary information from the records of a well-organised army for furnishing exact replies to the following questions: How many men were wounded in a given campaign? Of this number, how many died on the field? How many eventually died from the effects of their wounds? How many returned to duty with their corps, during the campaign and subsequently? and how many were discharged as unfit for further military service on account of their injuries? But on examining military statistical records, it will be found that in hardly any instance are the figures supplied from which this information can be obtained. And, upon consideration, it may be readily understood why these records are usually so defective. The frequent changes of hospital residence, in time of war, before a wounded soldier reaches the one where he is finally disposed of; the casualties which occur while the patients are *in transitu*; irregularities in furnishing hospital returns; occasional errors and deficiencies in them; the interruptions which frequently result merely from the rapid succession of events; the changes from one occupation to another of the medical officers in charge of patients,—these, and other such

circumstances, constantly act as impediments to getting complete and accurate information furnished at the time the occurrences take place, while the difficulties in the way of collecting it subsequently are almost insuperable.

To give the final results in respect to British troops accurately, not only the wounded men who die while under treatment, in the hospitals at the seat of war, or who are sent back to duty from them, or discharged to be invalided to England, must be shown; but also those who die while on the way between the various hospitals, on the sea passage home, and after arrival in England. Those who are discharged from the home hospitals to duty, or discharged as invalids out of the service, must also be duly tabulated. Only by all these means, taken together, can the final results of the injuries inflicted in action be really shown. And of those soldiers even who return to their regiments, some, after a short time, prove themselves to be incompetent for the duties which devolve on them, and have to be discharged from further service. Thus the final results of the injuries inflicted in any given war can only be accurately shown after a certain time has elapsed subsequently to its conclusion. But, for all practical purposes, it is generally sufficient to exhibit the results up to the time of the disposal of the wounded men on the completion of the period of treatment for the wounds which have caused their admission to hospital. This, it need hardly be said, will comprehend the whole course of treatment in the various hospitals to which the patient may have been admitted, whether by transference from one field-hospital to another, from the seat of war to the home country, or from one home hospital to another.

Ultimate results of the wounds inflicted during the Crimean war in the British army.—The whole of this information is complete as regards the British troops who were wounded during the Crimean War, and is shown in the following tables.[61] I am unable to furnish the same complete information in respect to any other war in which our own or other troops have been engaged. It will most probably be given in the Surgical History of the war of the Rebellion in the United States when the valuable history, which is in progress, is completed; for great pains were taken to obtain a knowledge of the condition of the wounded after the war was terminated, while continued efforts have been since made to complete the information as fully as possible.

Wounds and Injuries received in Action. Results of Hospital Treatment.

War	Number of Wounds among British Troops admitted into Hospital	Died in the Field and General Hospitals, or on board ship to the Bosphorus	Discharged to Duty	Invalided to England
Crimea .	11,515	1758	6139	3318

Invalided to England	Died on passage home	Died in Hospitals in England	Discharged to Duty	Discharged from Service
3318	13	4	290	3011

The final disposal of the 11,515 wounded admitted for hospital treatment was then as follows:—

Number of Wounded admitted into Hospital	Died in hospital or on board ship	Percentage of Deaths	Discharged to Duty	Percentage of Discharged to Duty	Discharged from further Service	Percentage of Discharged from further Service
11,515	1775	15·41	6729	58·44	3011	26·15

Application of the foregoing statistics.—If these and previous data be applied to injuries as they occur on a field of battle, then, out of every 100 casualties, there may be expected to be 20 deaths on the field itself, and, of the remaining 80 wounded who survive to come under hospital treatment, about 12 (12·33) may be expected to die; about 47 (46·75) to be cured, and to be discharged to duty; and about 21 (20·92) to be discharged as invalids from further service.

Ultimate results of wounds on other occasions.—A tabular account of the final disposal of the French wounded during the Crimean War cannot be given with the same exactness, because the 'Guéris ou Evacués,'—patients whose wounds had become healed, or who were discharged for transfer to other hospitals,—are counted together in the history; at the same time that no distinction has been made in either case between those who did, and those who did not, return to duty. The same remark applies to the French surgical history of the Italian War of 1859. It is to be presumed that Dr. Chenu could not obtain the necessary data to enable him to complete his admirable statistics of these wars so far as the points of information under consideration were concerned.

With regard to other recent wars in which Great Britain has been engaged, the information on the heads mentioned is also incomplete. The history of the New Zealand War, already quoted, affords full information up to the time of the invaliding of the wounded men to England, but the final disposal of these invalids is not recorded in it. These remarks are also applicable to the account of the Ashanti War.[62] The information respecting the final disposal of the wounded among the British troops in the Indian Mutiny of 1857–59 is also only partially recorded, for the records only show the disposal of those who were invalided home to England—the numbers of those who were wounded and died in India, and of those wounded who returned to duty among them, have not been placed on record.

The absence of the information is not a matter of much im-

portance as regards the wars in which British troops have been employed of late years,—the Indian Mutiny, New Zealand and Ashanti Wars,—on account of the nature of the weapons with which the enemies opposed to them were armed, but it is to be regretted that this information is not forthcoming in respect to some recent European campaigns; for, if it had been, many statements concerning the increased fatality of wounds produced by the improved weapons of recent dates, and the increased disabling effects attributed to them in those who survive, might be subjected to more exact tests than are at present available.

APPENDIX.

NOTES AND REFERENCES

Arranged and Numbered according to Sections.

SECTION I.

PRODUCTION OF GUNSHOT WOUNDS.

Shot from air-guns, note 1, page 2.

Mr. Syme has described a case of gunshot wound of the foot from an air-gun, in which the ball lodged, and injured the metatarsal bone of the great toe. The chief interest of the case arose 'from the effects of the wound so closely resembling those inflicted by the force of gunpowder'—*Monthly Journal of Medical Science*, Edinburgh, March 1850, p. 244.

Wounds resembling gunshot wounds, note 2, page 4.

Dr. Livingstone has remarked that a wound from the teeth of a lion has the same characters as a gunshot wound. In his 'Missionary Travels in South Africa,' 1858, he writes: 'Lions' teeth not only lacerate but crush the flesh as does a rifle bullet; and, as in the case of a gunshot wound, extensive sloughing follows.' The enormous muscular force, and the rapidity with which the teeth are forced through the flesh, especially when the animal is in a condition of rage, explain the effects Dr. L. has described in the foregoing passage, and which he unhappily experienced in his own person. These results, undoubtedly, bear a strong resemblance to those from gunshot injuries, but the wounds themselves are obviously wanting in several of the features by which wounds from gunshot are usually characterised.

Size of gunpowder grains, note 3, page 7.

Before rifled guns were introduced, gunpowder for large guns was known as L. G., or 'large grain,' to distinguish it from small arm powder, which was known as F. G., or 'fine grain' powder. A powder of larger grain was subsequently introduced in 1860: R. L. G., or 'rifle large grain.' Its size was such as to be retained upon a sieve of eight meshes to the inch, and to pass through one of four. The grains are angular, highly glazed, and one pound contains 13,000 of them. As guns became larger a larger grain was introduced. In 1867 'pellet' powder came into use. One of these grains, or pellets, is a disc of about the size

of a sixpence, with a depth of half an inch. Subsequently 'pebble' powder was introduced in 1869. In this powder the grains are more irregular in form, more compressed, and, therefore, of higher density. They resemble black pebbles of about half an inch in diameter, or of about the size of a common marble. The powder used in the experiments with the 81-ton gun has been angular in outline, and has varied in size from 2-inch cubes to 1½-inch cubes. The powder used for rifled portable arms is of a size to be retained on a sieve having 20 meshes to the inch, and to pass through one having 12 meshes. The glazing of the grains of fine powder is produced by their being rubbed against each other in machines made for this purpose; the glazing of some of the large grain powder is assisted by the addition of plumbago.

Force exerted by exploded gunpowder, note 4, page 7.

Bunsen and Schischkoff, experimenting upon one gramme (15·43 grains) of sporting powder, determined the amount of heat due to the actual combustion of the powder to be 619·5° C. (1115° F.), and calculated the temperature of the flame produced by the combustion to be 2,993° C. (5,419° F.). They also estimated the maximum pressure exerted by the gases at the first instant of evolution on the inner surface of the gun and on the projectile at 4,374 atmospheres—Quoted from Pogg. Ann., c. ii. 321; Wagner's Jahresb. 1857, p. 131; 1858, p. 158. Art. 'Gunpowder' in Watts' 'Dictionary of Chemistry,' 1864.

Fulminating powder, note 5, page 7.

The composition for the percussion caps used with English rifles contains fulminate of mercury, 4 parts; chlorate of potash, 6 parts; ground glass, 2 parts; the last being used to cause more friction among the particles. Sulphide of antimony is added in some compositions of a similar kind.

Bombard, note 6, page 12.

The word 'bombard' is now no longer in use as a substantive, though it is still retained as a verb, and in the artilleryman's title of 'bombardier.' The sound resulting from the discharge of the gun led to the origin of the name: 'bombus,' or 'bombardus,' being Latin for the blast of a trumpet.

Early use of guns, note 7, page 12.

'It is affirmed that in this memorable battle' (battle of Crécy, or Cressy, fought on August the 26th, 1346) 'the English began for the first time to use cannon, a thing yet unheard of in France. Four pieces, planted on a little hill, did great execution among the French troops, and struck them with such terror, that the success of this day is partly ascribed to the surprise of the French at this novelty.'—Rapin, translated by N. Tindal, 2nd edition, vol. i. p. 425.

Size of early guns, note 8, page 12.

The size to which iron cannon, or bombards, were cast is shown by an accident which is quoted by various writers as having occurred in the year 1478. In this instance, the projectile used with the gun weighed 5 cwt.; and as the maker of the gun, and a number of other persons were engaged in lowering one for a second discharge, the gunpowder suddenly exploded, casting out the ball, and, at the same time, bursting the piece. Sixteen persons are said to have been killed by the ball itself and six others by fragments of the gun.

Round shots or cannon-balls, note 9, page 14.

Balls, from βάλλω, to cast. Curiously, the terms in France for cannon balls and musket bullets were the reverse of the corresponding terms in English. 'Boulets,' the diminutive of *boule*, or *balle*, was used for cannon-balls, or gun-shot; 'balles,' for musket or pistol bullets.

Bolts, note 10, *page* 14.

A very old designation of cannon shot, used as early as the year 1418. It had been previously employed for arrows shot from cross-bows, and had the same derivation as the term 'ball.'

Shells, note 11, *page* 17.

During the Franco-German War, the Prussian field artillery consisted chiefly of breech-loaders, the French of muzzle-loaders. It has been asserted that the former had not only the military advantages of superior range and precision, but also that the shells used with them broke into a considerably greater number of fragments.

Arquebus, note 12, *page* 28.

The derivation usually given is arc-à-bouche; *i.e.*, bow with a mouth. That given by Ambrose Paré in the preface to the book 'des playes faites par harquebuses,' in the second edition of his complete works, published in 1579, is probably the correct derivation. His remarks translated are:—'*Harquebuse* is a word taken from the Italians, because of the touch-hole by means of which the fire from the pan passes forward into the barrel of the gun, for the Italians call a hole *buzio*; and it is called *arc*, because it is now used as arcs (bows) were formerly used in war, the archers being then advanced in front, as the Harquebusiers now are, in battle.' In Latin works of the period the term 'Archibusum' was used; thus the title of the book published by Alfonsus Ferrius, at Rome, in 1552, was 'De Sclopetorum, sive Archibusorum, Vulneribus.'

Stone bullets, note 13, *page* 28.

In Gale's first chapter, which contains arguments evidently borrowed from Ambrose Paré against the prevailing notion of gun-shot wounds being poisoned wounds, he does not refer to the effects of *leaden* shot being lodged in wounds, which he would probably have done had they been in common use. To prove that the shot does not become so hot during its flight as to form an eschar, or to burn the part wounded, he puts forth the following experiment:—'Hange a bagge full of gonnepouder on a place convenient, and then stand so far off as your peece will shote leavell, and shute at the same, and you shall see the gonnepouder to bee no moore set on fyre with the heate of the stone, than if you cast a cold stone at it.' He makes only one allusion to a 'pellet of leade,' which he took out from a soldier who had been shot some time before at the siege of Pavia.

Pellet, note 14, *page* 28.

This was one of the first names used for a bullet, and was apparently derived from the Latin 'Pila,' a ball. Gale in his treatises uses the words 'shotte' and 'pellets' indifferently: I have not met with the term 'bullet' in his writings. It is curious to observe how completely its use has disappeared in respect to leaden bullets, though we still hear boys talking of the pellets of their pop-guns. The pharmaceutical word 'pill' is evidently another form of the same term; as 'bolus' also appears to be an Anglicism of the Greek βῶλος, a ball or shot.

Fusileers, note 15, *page* 29.

The three Fusileer regiments raised at this time were the 21st Fusileers in 1670, the 7th Fusileers in 1685, and the 23rd Fusileers in 1688. The French word 'Fusil' seems to have been taken from the Italian 'Focile,' which means the piece of steel employed for striking flint and producing fire; as this, again, was derived from the Latin 'Foculus,' diminutive of 'Focus,' a fire-hearth.

Leaden bullets, note 16, *page* 29.

Colonel Anderson, Superintendent of Machinery to the War Department, informed me that spherical bullets were first made by compression in the year

1840. Mr. David Napier was the inventor of the machine, and it was in use in the Royal Arsenal until about 1855. The lead was melted and cast into rods, about five feet long; these were held by hand to the compressing machine, and the projecting rim or 'frill,' formed at the junction of the dies, was afterwards removed by hand also. Elongated bullets were first made by compression in 1851. The lead was now squirted while solid into a long rod, and this was wound upon a reel like a rope. The end of this leaden rod was then given to a self-acting machine, which delivered the bullets complete without the need of any handling.

Foot-pounds, note 17, *page* 36.

The term 'foot-pound' is used for the force required to raise a pound weight one foot from the ground, or, in other words, the force with which a pound weight falls to the ground by gravity from a height of one foot.

Weight of Chassepôt bullet, note 18, *page* 40.

The weights really varied between 375 and 398 grains. One specimen in the Military Surgical Museum at Netley, weighs 398 grains, another 396 grains, while several taken from cartridges obtained during the Franco-German War weigh only 375 grains.

Note 19, *page* 41.

Gurlt. 'Military Surgery Fragments,' 1864.

Small shot, note 20, *page* 42.

Museum of Military Surgery, Netley, case No. 594.

Ashanti War, note 21, *page* 44.

Numbers extracted from Army Medical Reports, vol. xv. 1875, p. 258. The troops left the Gold Coast at the end of February, 1874. The deaths enumerated are up to the 31st of May, 1874.

Treaty regarding explosive bullets, note 22, *page* 48.

The following is the text of the convention of St. Petersburg relative to these projectiles. Its date is the 16th of November, 1868.

'Considering—that the progress of civilization ought to have the effect of lessening as much as possible the calamities of war;

'That the only legitimate object that States ought to propose to themselves during war is to weaken the military strength of their enemies;

'That, for this purpose, it is sufficient to put *hors-de-combat* the greatest number of men possible;

'That this end would be overpassed by the employment of arms which would uselessly aggravate the wounds of men placed *hors-de-combat*, or that would render their death inevitable;

'That the employment of such arms would be consequently contrary to the laws of humanity;

'The undersigned, having received the orders of their Governments in this respect, are authorised to declare as follows:

'§ 1. The contracting powers mutually bind themselves to renounce, in case of war among themselves, the employment by their land or sea forces of all projectiles, charged with explosive, or inflammable matters, of a less weight than 400 grammes.

'§ 2. They will invite all the States which have not sent delegates to the military international commission at St. Petersburg, to accede to the present engagement.

'§ 3. This engagement is only obligatory upon the contracting or acceding parties, in case of war between two or more of themselves; it is not binding in regard to parties who have not joined the convention.

'§ 4. It will equally cease to be obligatory, from the moment when, in a war between powers which have joined the convention, another power not a party to the convention, shall join one of the belligerents.

'§ 5. The contracting and acceding parties will come to a further understanding among themselves, every time that a precise proposition shall be made on the subject, as regards future improvements that science may make in the arms of troops, so that the principles which they have laid down for reconciling the necessities of war with the laws of humanity may be maintained.'

Use of explosive bullets, note 23, page 48.

See articles on this subject in the *Times* of the 9th of December, 1868, and several others about the same date, in the *Pall Mall Budget* and other newspapers.

SECTION II.

CAUSES WHICH INFLUENCE GUNSHOT INJURIES.

Shapes of bullets, note 1, page 55.

Preps. Nos. 2926 B and 2926 D. See Descriptive Catalogue of the pathological specimens in the Museum of the Royal College of Surgeons of England, pp. 92, 93.

Deformed bullets, note 2, page 58.

The Museum of Military Surgery at Netley contains many examples of the strange shapes presented by deformed bullets extracted from wounds. Some admirable drawings of bullets extracted from wounds, which had been previously altered in shape by ricochetting from walls, or which had become deformed from other causes, may be seen in the beautiful atlas of plates accompanying Dr. Chenu's 'Med. Chirl. Statistics of the Campaign of Italy, in 1859-60.'

Russian bullets, note 3, page 65.

The heaviest Russian bullet, from the Crimea, in the collection of the Army Medical Museum at Netley, is a solid, pointed, two-grooved, rifle bullet, weighing 772 grains.

Minié rifle bullet, note 4, page 65.

The large size and weight of this projectile seem to have been due to the influence of the Duke of Wellington. It is stated in his life by G. R. Gleig, Chaplain-General to the Forces, (London, 1864, p. 397), that when the 'Minié' musket was introduced 'the one point to which the Duke adhered was, that the old bore should be retained: partly because the greater size of the English bullet had rendered it much more effective than any other in former wars; partly because, in the event of the stock of conical bullets running short, the troops, in case of emergency, would be able to use the cartridges which were already in store.' The effects referred to by the Duke were probably more due to the smashing and stopping qualities of the spherical shape of the old bullet, than to its mere size and weight: an elongated bullet of the same amount of metal would not have possessed the qualities mentioned in the same degree. See remarks on the shapes of projectiles in the text.

Effects of velocity of bullets, note 5, page 70.

John Hunter's Works. Part iv. 'of Gunshot Wounds,' ch. i. § i. par. 5.

Primary healing of bullet wounds, note 6, page 71.

My friend, Dr. Moffitt, has recorded a case under his care in China, in which no purulent discharge was known to have occurred from the track of a small projectile, and which apparently became healed by primary adhesion. But, even in this instance, the integuments, both at the wound of entrance and at that of exit, sloughed, and a small sore formed at each place which had to be treated in the usual way. Dr. Moffitt mentions that the muskets used by the Chinese against Gordon's force, of which he was in medical charge, were of the smooth-bore kind; the bullets were small, did not fit the firearms, the powder was inferior, and, owing to the small amount of force possessed by the projectiles in consequence of these circumstances, there was seldom much disorganisation of wounded structures. In the case mentioned, the small bullet appeared to pass through the areolar tissue connecting the soleus muscle with the intermuscular fascia which binds down the deep layer of muscles of the back of the leg: and it may be well understood how, under such circumstances—the projectile meeting scarcely any resistance to its passage—speedy closure of that part of the track without escape of matter might readily occur.

After the remarks in the text on this subject were written, Professor Esmarch was kind enough to send me his essay, entitled 'Die antiseptische Wundbehandlung in der Kriegschirurgie.' In this paper, Dr. Esmarch speaks of most severe gunshot wounds healing by simple primary union, without any suppuration, before the introduction of Lister's antiseptic treatment. He refers to such wounds as severe gunshot fractures of the thigh and perforating wounds of joints, healing like subcutaneous wounds, without suppuration (ohne Eiterung, wie subcutane Wunden) not only in his own experience, but also in the experience of many other eminent German surgeons: even bullets, driven into bones and joints, becoming inclosed, and healed over, without exciting suppuration or inflammation. In some portions of the remarks, however, similar cases are referred to as having healed, almost without suppuration, (fast ohne Eiterung), and it seems doubtful whether this qualifying expression may not be applicable to all the cases referred to. If, however, the observations regarding the grave and complicated wounds, mentioned as having healed without any suppuration, are to be taken literally, I cannot but regard them as remarkably exceptional cases; for, as I have observed in the text, I have never been able to meet with any English military surgeon who has had similar experience.

Spent shot, note 7, page 75.

A Private of the 1st Battalion 20th Regiment was admitted into Fort Pitt in September 1859, who had been struck a year before near Lucknow, by a spent gunshot, about 2 inches above the external malleolus of the right leg. Simple fracture of the fibula and tibia resulted. The skin was not broken by the projectile, and union of both bones was completed without sloughing or ulceration of the soft parts. The soldier was discharged from further service on account of impaired power in the limb, owing to deformity which had been allowed to occur during the process of union.

Spent shot, note 8, page 76.

'La Guerre de Crimée,' par L. Baudens, 1858, p. 124.

Effects of rotation on penetration, note 9, page 79.

One of the most remarkable instances that I am acquainted with of a round bullet being deflected by a yielding surface is the following, which was related to me by my friend Colonel Onslow. One day, about the year 1833, when the 54th Foot, under Colonel Mildmay Fane, were assembling for parade at Trichinopoly, a soldier stepped up to Lt.-Colonel Reed, the second in command, and made a request to him. This officer was on horseback, and had in his hand a limp rattan cane, about the thickness of a little finger, which he was moving

up and down in front of his face. Colonel Reed's reply to the man was to the effect that he ought to make his request through the Captain of his company. The soldier, remarking, 'Oh! that's it, is it?' immediately levelled his musket at Colonel Reed and fired. The bullet happened to strike the cane in front of his face, ran up it, and was thus diverted from hitting its intended object. Colonel Reed's life was saved by this slight obstacle, for the shot was in a direct line for his head. The soldier was condemned to death, and the sentence was executed. Colonel Onslow, who was on the man's court-martial, informed me that the cane retained the mark where the bullet had struck it, from which point it was split up to the top.

Rotation of rifle projectiles, note 10, *page* 80.

Major Owen, Professor of Artillery at the Royal Military Academy, Woolwich, has stated in some remarks on the motion of projectiles: 'There is no doubt but that the rotatory motion of a projectile fired from a rifled gun greatly increases the penetration;' and again, 'Velocity of rotation increases penetration.' —*Royal United Service Inst. Journal*, vol. vi. pp. 231-233.

Rotation of spherical bullets, note 11, *page* 82.

Percy, Dupuytren, Baudens, and others refer the conical shapes of bullet tracks to the special cause named in the text. Baudens gives the same explanation as Percy, 'The bottom of the wound is larger than the wound of entrance, owing to the persistence of the movement of rotation, which lasts longer than the movement of projection.'—'Clinique des Plaies d'Armes à feu,' par M. L. Baudens, &c., Paris, 1836, p. 17.

Lead melting from quickness of flight, note 12, *page* 85.

'Stridentem fundam, positis Mezentius hastis,
Ipse ter adductâ circum caput egit habenâ,
Et media adverso *liquefacto* tempora plumbo
Diffidit, ac multâ porrectum extendit arenâ.'
Virgilii Æneidos lib. ix. l. 586-589.

'Balearica plumbum
'Funda jacit, volat illud et incandescit eundo,
Et quos non habuit, sub nubibus invenit ignes.'
Ovid. Met. ii. 730-732.

Heat of bullets, note 13, *page* 85.

Gale argues the point in the following terms: 'But that you shall perfectlye understande and be judge your selfe in this case. Hange a bagge full of Gonnepouder on a place convenient; and then stand so far of as your peece will shote leavell, and shute at the same, and you shall see the gonnepouder to bee no moore set on fyre with the heat of the stone, than if you caste a colde stone at it.' —Gale, op. cit. p. 6. It is curious that a namesake of Gale has in our own time in a certain sense destroyed the value of this proof by showing that the gunpowder not being fired is no proof that the shot is destitute of heat; he, on the contrary, putting even red-hot shot into gunpowder without the latter being 'set on fyre.'

Heat of projectiles, note 14, *page* 86.

By Dr. Hagenbach's calculation, the impetus of the ball ($\frac{m v^2}{2}$) was equal to 209 kilogrammetres, and its mechanical equivalent of heat, 0·49 thermal unit. The entire projectile (40 grammes) had to be raised to near the temperature of the melting point of lead: and the 27 grammes (only 13 grammes being unmelted) had to be melted. Assuming 100° C. as the initial temperature of the bullet, which was somewhat warmed by the heat of combustion and friction, the melting point of lead being 335° C., its specific heat 0·031, and its latent heat of

fusion 5·37, he finds necessary for heating 0·29 thermal unit, and for fusion 0·15; giving a total of 0·44 thermal unit, this being only ·05 less than the estimated mechanical equivalent (see Poggendorf's 'Annalen der Physik und Chemie,' Band 140, p. 486, 1870). In a subsequent volume of the same journal (Band 141, p. 594, 1871) Mr. J. Bodynski criticises Dr. Hagenbach's calculation, and shows that the impetus ($\frac{m v^2}{2}$) was really equal not to 209, but to 2,048 kilogrammetres; and that, consequently, 424 kilogrammetres being equal to 1 heat unit, the total heat developed would be 4·83 heat units. But 4·83 heat units, if wholly expended in melting lead, would suffice to melt 381 grammes, not 27 grammes: the excess of heat, however, is really expended in the manner explained in the text.

Poison of gunshot wounds, note 15, page 90.

Paré gives the following account of the occurrence referred to in the text. He had gone into Sardinia in 1536, as surgeon of General Montejan who held a command in the army of Francis the First of France. When alluding to an engagement in which there were many men wounded by bullets on both sides, he writes:—'I will tell the truth, I was not very expert at that time in matters of chirurgery; neither was I used to dress wounds made by gunshot. Now I had read in John de Vigo, that wounds made by gunshot were venenate, or poisoned, and that by reason of the gunpowder; wherefore for their cure, it was expedient to burn them with oil of elders, scalding hot, with a little treacle mixed therewith. However, as I gave no great credit to the author or his remedy, from knowing that caustics could not be poured into wounds without excessive pain, I determined before I would run any risk to see whether the surgeons who were with me in the army used any other kind of dressing to these wounds. I observed that all of them used the method of dressing prescribed by Vigo, and that they filled, as full as they could, the gunshot wounds with tents and pledgets dipped in this scalding oil at the first dressing, which encouraged me to do the same to those who came to me to be dressed. It chanced on a time that, by reason of the multitude who were hurt, I was in want of this oil. Now because there were some few left to be dressed, I was forced, that I might not seem to be without anything needful, and that I might not leave them undressed, to apply a digestive made of the yolk of an egg, oil of roses, and turpentine. I could not sleep all that night, for I was troubled in mind; the dressing of the preceding day (which I judged unfit) disturbed my thoughts; and I feared that the next day I should find those whom I had not dressed with scalding oil dead, or at the point of death, from the poison of their wounds. I therefore rose early in the morning, visited my patients, and, contrary to expectation, I then found such as I had dressed with a digestive only free from excessive pain, that they had had good rest, and that their wounds were not inflamed nor tumefied; while, on the contrary, the others that were burned with the scalding oil were feverish, tormented with much pain, and the parts around their wounds were swollen. When I had tried this many times in others, I thought thus much,—that neither I, nor any other, ought ever to cauterise wounds made by gunshot.'

Dailly, note 16, page 90.

The following is the title of the work referred to:—'Traité des Blessures et Playes faites par armes à feu, vulgairement dites playes d'Arquebusades. Auquel sont amplement expliquées leur nature et curation avec la manière de corriger les accidents qui les accompagnent, le tout avec méthode. Mis en François par Pierre Dailly, Maistre Chirurgien Juré à Paris. À Paris, chez André Boutonné, au Palais, vis-à-vis la Sainte Chapelle, à la belle estoille, 1668.' The work is divided into thirty-five chapters. The first chapter, 'De la nature et essence des playes d'Arquebusades,' and the seventh chapter, 'On l'on détruit l'opinion de ceux qui rejettent la qualité veneneuse des playes d'Arquebusades,'

contain the arguments adduced by the author to show that gunshot wounds are poisoned wounds. The chief among them are:—That though the constituents of gunpowder are harmless separately, they acquire a poisonous quality when mixed; when forced into a porous leaden bullet, though itself small, it retains sufficient to acquire a poisonous influence; that balls and other foreign bodies which inflict wounds are very often designedly poisoned by malice of enemies, by being steeped in poisonous juices, of which part are retained, enough to infect the frame of a wounded man; that common observation shows that gunshot wounds, though slight, become great and incurable and finally cause death; that charring and blackening (bruleures et noirceurs) are evident in them; and that the wounded are attacked with faintings, palpitations, maux de cœur, mortification of limbs, and various accidents, which would be otherwise inexplicable. There is a good copy of Dailly's work in the British Museum Library. The name of the author is given in the catalogue as D'Ailly, but Dailly is the correct name, as shown at the end of the prefatory epistle, and also in the 'Extrait du Privilège du Roy.' The first two letters are accidentally separated in the title-page of the book, but there is no apostrophe between them.

Poisoned bullets, note 17, page 91.

'Des Plaies d'armes à feu; communications faites à l'Académie Nat. de Médecine,' Paris, 1849, p. 9.

Note 18, page 91.—Op. cit. supra, p. 83.

Note 19, page 92. Clowes, to determine whether 'the flame of the fire out of the peece doth extinguish and kill the force and strength of any poisoned shot,' got the Master Gunner at Portsmouth to let one of the soldiers fire an arrow out of a musquet. The soldier, 'taking his rest' at 200 paces, caused the arrow to stick deeply in the post of a gate, when, it was found, 'not one feather was touched with flame or fire.' Clowes relates that he had 'since seen the like done with our common sheafe arrows in a caliver,' and concludes that 'this proveth the fire cannot burn out the impression of a poisoned bullet.'

Among the cases of gunshot wounds recorded by Clowes is one of an officer who was wounded in the right natis by a musket bullet. The missile lodged, and was followed by great ædema, pain, general anxiety, &c. Clowes consults a physician in the case, whose advice is 'To make deepe incision, and then with a pair of tenacles to take hold of the bullet and to bring it out so easily as may be; then to scarifie well the lips or sides of the wound, which done, yee shall presently set on a strong cupping glasse or a flame of fire, that yee may the better evacuate and draw out the venomous and poisoned blood which lurketh deeply in the bottom of the wound.' Clowes mentions that he treated the case according to this advice, and the patient recovered. He notices that, on extracting the bullet, he found it strangely indented and marked with unusual colours, which colours, on the lead being melted, went away. It is curious to observe, when a preconceived opinion prevails, what ordinary circumstances are turned to its support. The case quoted is headed 'Cure of a Lieutenant which was shot in the right buttock with a poisoned bullet.' See Clowes' Works, edit. 1596, pp. 44-50.

Angle of impact, note 20, page 93.

Sir Gilbert Blane in his account 'Of the wounds received in the actions of April 1782,' ('On the Dis. of Seamen,' 3rd edit., 1803, p. 575), refers to two instances of a ball passing close to the stomach and producing instant death, life being destroyed, 'without any visible external injury or breach of the parts, nor any appearance of the body from whence the injury proceeded.' He also relates the case of a man whom he attended, who had the buttons of his trousers carried off by a cannon-ball without any breach in the skin, but who suffered for nearly three months afterwards from paralysis of the bladder. Mr. Ellis, (op. cit. infra), refers to the case of Captain M., of the Bengal Native Infantry, who, while serving in Lord Lake's army, lost the sight of both eyes by the pas-

sage of a cannon-ball across his face, which, however, inflicted no external mark of injury; also, to the case of an officer in the trenches at the siege of Bergen-op-Zoom, who, while in the act of stooping to assist a soldier who had fallen, lost instantaneously the sight of one eye, and gradually that of the other, in consequence of a cannon-ball passing across his face without touching it.

Note 21, *page* 95.—J. Brown, surgeon to Charles II., afforded an example in his own person of an erroneous impression, such as is described in the text. He had his arm broken by a cannon-shot, and attributed the injury to the effects of windage. When remarking on the discolouration of gunshot wounds being due to the force of contusion, he writes:—'The which I am sufficiently satisfied in, having been made an example of the same in the Dutch Wars by the wind of a 24-pound bullet, by which my arm was miserably fractured and contused.'—See ch. xviii. of 'A Compleat Discourse of Wounds both in General and Particular, &c.,' by John Brown, Sworn Chirurgeon in Ordinary to the King's most Excellent Majesty, London, 1678.

Injuries from windage, note 22, *page* 95.

I have found the notion that the 'wind of shot' could produce injuries in some of the earliest writings on gunshot wounds. In the work of Alf. Ferrius, 'De Sclopetorum sive Archibusorum vulneribus,' published at Rome, in 1552, and in the 18th chapter of the 2nd book, 'De majorum bellicorum fulminum contusionibus,' there occurs the following passage—' fieri enim forte fortunâ potest, ut non semper interimant, sed contundant tantum, vel ictu, vel etiam spiritu, &c.'

Note 23, *page* 95.—Dr. Spence observes in his remarks on this subject: 'I know an officer who had considerable pain in the loins for some time after a battle, supposed to be from the wind of a shot, as he was not conscious of anything having hit him, and there was no external mark; but the flakes of a bed from the hammock-nittings being pretty thick on his coat, showed to me that the pain was produced by something more dense than wind. As to the fact of cannon-balls carrying light substances with them, they so very seldom stick in the body, I have had no opportunity to ascertain positively that they do; but with grape-shot, canister-shot, and musket-balls, I have had ample testimony; and I think there is every reason to believe that cannon-balls do also, from the many pieces carried away where the shot have hit or passed through; and it is also pretty evident on sweeping the decks after a battle.'—'Observations on those Accidents commonly ascribed to the Wind of a Ball.' G. T. Spence, M.D., Surgeon R.N., in the *Edinburgh Medical and Surgical Journal*, vol. viii., p. 161.

Note 24, *page* 95.—See 'Observations on the Nature and Cause of certain Accidents which sometimes occur in Battle, and have been usually ascribed to the Wind of a Ball,' by Mr. Ellis, in the *Edinburgh Medical and Surgical Journal* for Jan. 1812.

Note 25, *page* 95.—Frequent reference to injuries from windage is made in military writings. The following quotation, from memoirs written by an officer who served during the late war of the rebellion in the United States, is illustrative of the belief in them which is still impressed on the minds of combatants:—'I pushed on, and reached the point of my destination in safety; but galloping back, I felt a stunning blow across the spine, and at the same moment my horse rolled over with me. I was confident the animal had been struck by a cannon-ball; but to my great surprise, I was not able to discover any wound. As I was myself unhurt, I remounted my brave animal and continued my way. A solid shot had passed close to my horse's back, and the current of air set in motion by its passage had knocked over both horse and rider. Afterwards, during the war, I witnessed many similar cases of prostration of men and animals by windage.'—'Memoirs of the Confederate War of Independence,' by Heros von Borcke, chief of the staff to General J. E. B. Stuart, *Blackwood's Edinburgh Magazine*, vol. xcviii. Oct. 1865, p. 392.

Note 26, *page* 95.—Mr. Bransby Cooper used to relate an instance which came under his own observation of the little effect produced by the 'wind of a ball.' When he was an assistant-surgeon of the Royal Artillery, and on duty near Bayonne, he saw a 32-pounder shot pass between the outstretched thighs of an artillery officer at the time he was sighting a gun. It caught and carried off the tail of his uniform coat, but did no further injury whatever. Mr. Cooper's faith in the wind of a shot having any power to hurt a person was shaken from the date of this occurrence.

Elasticity of skin, note 27, *page* 98.

A full report of this case may be seen in the *British Medical Journal* of August 20, 1870.

SECTION III.

CHARACTERISTIC FEATURES OF GUNSHOT INJURIES.

Wound from a bullet at its highest rate of speed, note 1, *page* 104.

It is right to mention that, even under the circumstances described in the text, the skull may possibly not be perforated by the bullet. There is a remarkable preparation in the Pathological Museum at Netley, taken from a suicide who discharged a loaded Enfield rifle, with the muzzle placed below his chin. There was no wound of exit. The bullet and its wooden plug were found flattened against the occipital bone (see Cat., App. 2, No. 480).

Rasing shot, note 2, *page* 110.

From the French *raser*, to shave. 'La balle lui rasa le bras': 'the bullet scored his arm.' It is in common use as a military term; thus, *Rasing fire*, the fire from the *rasant* flank of a bastion. It is sometimes written 'grazing,' but is properly as above.

Gaseous projectiles, note 3, *page* 115.

'Erichsen's Surgery,' 6th edit., vol. i. p. 162.

Note 4, *page* 118.—'Surgical History of the Crimean War,' p. 310.

Note 5, *page* 118.—'Notes of an Ambulance Surgeon,' by Wm. MacCormac, F.R.S., Lond. 1871, p. 49.

Note 6, *page* 118.—'Dr. Roberts' Report of the 4th Divn., &c.'—*Med. Times and Gazette*, February 23, 1856, p. 184.

Magazine Explosions, note 7, *page* 118.

'Campagne d'Orient en 1854 56,' par J. C. Chenu, &c., &c.; Paris, 1865, p. 118.

Note 8, *page* 118.—The quantity of gunpowder exploded, and the number of casualties on the French side, were given at much higher figures at the time of the occurrence of the accident. Mr. Russell states in his 'Diary' that the quantity of gunpowder blown up in the French Parc de Siège was: Russian powder, about 1,700 barrels: French powder, about 800 barrels: or a total of about 250,000 lbs., irrespective of that contained in shells, rockets, and small-arm ammunition. He also relates that the French had 6 officers killed and 13 wounded; 65 men, chiefly artillerymen, killed and 170 wounded. The effects of this explosion are very graphically described by Mr. Russell (see 'The War, from the Death of Lord Raglan to the Evacuation of the Crimea,' by W. H. Russell, Lond. 1856, p. 350, &c.).

Note 9, *page* 118.—See Genl. Codrington's Despatch to Lord Panmure, dated November 17, 1855, and Adjt.-Genl. Pakenham's Returns enclosed. The force of the atmospheric wave from the explosion is well illustrated by the fact incidentally mentioned by Genl. Codrington, that windows were burst open and broken at the farm-house where the head-quarters were established. This building was distant two and a half miles from the place where the explosion occurred.

Tracks of bullets, note 10, *page* 124.

Legouest, 'Traité de Chirurgie d'Armée,' Paris, 1863, p. 339

Note 11, *page* 129.—'A Treatise on Gunshot Wounds,' by G. T. Guthrie, &c. London, 1820, p. 27.

Note 12, *page* 131.—'Relation Méd. Chir. de la Campagne d'Orient,' par le Dr. J. Scrive, Médecin en Chef de l'Armée, &c. Paris, 1857, p. 438.

Wounds by explosive bullets, note 13, *page* 132.

Specimens, Nos. 4,601 and 4,621.

Explosive bullets, note 14, *page* 132.

'Memoirs of the Confederate War of Independence,' by Heros von Borcke, chief of staff to Genl. Stuart, in *Blackwood's Magazine* for Oct. 1865, p. 406.

Note 15, *page* 132.—Specimen No. 4561 is the explosive projectile referred to. It is labelled, 'A conoidal bullet, considered to be a specimen of the explosive ball.' A drawing of the specimen is annexed. I have frequently seen a conoidal bullet, with an iron culot, assume a similar shape, when it has happened that the iron cup (not a very rare occurrence with the Minié bullet) had been driven through the projectile at the time of its discharge from the rifle.

Note 16, *page* 132.—See the 'Journal of the Royal U. S. Instn.' vol. xii., Lond. 1869, p. 16. art. 'Explosive Bullets and their application to Military Purposes.'

Note 17, *page* 133.—See a letter in the *Times* signed 'Marksman,' and dated December 10, 1868. The writer concludes that, as means of destruction, explosive bullets only cause useless mutilation, though for certain other military purposes they might occasionally be employed with considerable advantage.

Wounds by small shot, note 18, *page* 134.

I made a series of experiments with a breech-loading fowling-piece, using one of Eley's cartridges with No. 16 shot, about 250 in a charge, and, comparing them with the well-known experiments recorded by Dr. Lachèse, found the range at which the effects described by him were produced in all instances considerably extended. Thus, Dr. Lachèse records, that at a distance of 3 feet there was no longer any central opening from the shot; while in my trial at 15 feet there was still a central hole $1\frac{1}{4}'' \times \frac{3}{4}''$ in size, with scalloped edges and an irregular outline. About 100 shot had passed through this opening. Outside the central hole there were about 140 shot openings; some having passed singly, in other instances two side by side, in others three or more together, in others the shot combining to form an irregular rent, and all these being within a circle of about 7 inches in diameter. At 50 yards about 150 shot out of the 250 pierced a wooden target 8 feet high by 6 feet wide, generally penetrating the wood to their own depth. They were very widely scattered over the target, from top to bottom. The experiments of Dr. Lachèse showed great scattering of the shot at very short distances compared with the distances just mentioned. See 'Obss. et Expériences sur les Plaies Produites par des Coups de fusil Chargés à Poudre ou à Plomb, &c.' par le Dr. Lachèse Fils: 'Annales d'Hygiène Publique,' tome xv. 1836, p. 359.

SECTION IV.

PRIMARY SYMPTOMS AND COMPLICATIONS OF GUNSHOT INJURIES.

Pain of gunshot wounds of bones, note 1, *page* 142.

Dr. Chenu mentions the case of an artilleryman in the Italian Campaign of 1859, who had the neck of his left thigh-bone fractured by a bullet while he was loading his gun. The man, who had his leg advanced at the time and the weight of his body leaning upon it, went on with what he was about, unconscious of what had happened, though feeling a severe general shock; but, on presently making an effort to draw himself upright, he tottered, and only avoided falling by supporting himself against a tree ('Campagne d'Italie,' tome ii. p. 290). He has also related the case of a mounted officer who had the neck of the thigh-bone broken by a bullet in the Franco-German War. Although sensible of a dull blow, he had no conception of the severe injury that had happened to him until he saw his limb drop from the stirrup, and found himself unable to replace it there ('Guerre de 1870–71,' tome i. intro. p. 31).

Pain along bullet tracks, note 2, *page* 144.

Extract from 'Life in India and Scenes in the Mutiny,' a lecture delivered in Halifax, in 1860, by H. Chalmers-Miles, assist.-surgeon R.A. Halifax, N.S., 1860, p. 15.

Special sensory effects, note 3, *page* 145.

'Injuries of Nerves, &c.' by S. Weir-Mitchell, M.D., Phil. 1872, p. 146.

Hæmorrhage after gunshot wounds, note 4, *page* 152.

It appears that death from hæmorrhage may sometimes be prevented without any material contraction of the arterial tube and by quite a different process from that described in the text. Dr. Chenu has reported a case which came under his notice in the Franco-German War, in which an ignorant and careless operator amputated the thigh near the knee-joint not only without making any flaps, but, also, without placing any ligature on the vessels. The amputation was done at eleven A.M., and the patient was not seen by another surgeon until after six P.M. There had been no hæmorrhage. The state of the popliteal artery at this time is thus described: 'The aperture of the vessel was scarcely at all contracted, but was almost entirely closed by the folding and knitting together of the internal coats, which appeared to be turned on themselves, with a direction inwards.' Dr. Chenu likens the state of the internal coats of the artery to the turning up and shrivelling which parchment, exposed to the heat of fire, exhibits; and he attributes the absence of hæmorrhage to this process, together with the hæmostatic effects of the shock of the original injury (smashing and almost entire removal of the limb below the knee by a fragment of shell) and of the clot which had formed on the face of the stump after the amputation.—Chenu, 'Guerre de 1870–71,' tome i. p. 297.

Primary hæmorrhage, note 5, *page* 153.

Guthrie on 'Wounds and Injuries of the Arteries,' 1846, p. 22.

Note 6, *page* 154.—'Med. and Surg. History of the British Army in the Crimea,' vol. ii. p. 340.

Note 7, *page* 155.—Hunterian Museum. Prep. No. 1,565.

Lodgement of conoidal bullets, note 8, *page* 158.

'Kriegschirurgische Erfahrungen gesammelt in Carlsruhe, 1870–71,' von Dr. A. Socin, &c.: Leipsig, 1872, p. 15.

Lodgement of fragments of uniform, note 9, *page* 158.

The instances of such articles being lodged in gunshot wounds are very numerous. The fatal bullet which killed Lord Nelson entered his left shoulder, carrying a portion of his epaulette with it. The epaulette with the vacant hole in it is, or used to be, at Greenwich Hospital.

Lodgement of foreign bodies, note 10, *page* 160.

Catalogue of the surgical section of the U.S. Army Med. Museum, xxvii. BII. No. 3,236, d. 213.

Note 11, *page* 160.—'Relation Chir. des Évènements de Lyon,' 1835.

Note 12, *page* 161.—Chenu, 'Guerre de 1870–71,' tome i. p. 286.

Note 13, *page* 161.—'Kriegschirurgische Erfahrungen gesammelt in Carlsruhe, 1870–71,' von Dr. A. Socin, &c.: Leipsig, 1872, p. 21.

Note 14, *page* 162.—Hennen's 'Military Surgery,' 3rd edit. 1829, p. 87.

Note 15, *page* 163.—Hennen, supra cit. p. 85.

Lodgement of shell fragments, note 16, *page* 164.

'Histoire Méd. du Blocus de Metz,' par E. Grellois, ex-Méd.-en-Chef d'Armée, Metz, 1872, p. 63.

Concealment of foreign bodies, note 17, *page* 165.

For the history of this case see 'Cases and Communications illustrative of Subjects in Military and Naval Surgery,' by Sir G. Ballingall, *Edin. Med. and Surg. Journal*, vol. lvii. p. 116. Figures of the breech of the musket of full size, of the manner in which the foreign body protruded through the palate, and of a vertical section of the head showing the position in which it was lodged, accompany the history. An earlier history of the case, with some particulars not mentioned by Sir G. Ballingall, together with an additional drawing and an account of the post-mortem examination, are given in the *India Journal of Med. and Phys. Science*, vol. ii. N.S., Calcutta, 1837, p. 765. The history of the case is also repeated in Emerson Tennent's 'Ceylon,' vol. ii. p. 333.

Lodgement of the breech of a fowling-piece in the face for twenty-four years, note 18, *page* 166.

For the particulars of this case I am indebted to Mr. F. F. Giraud, of Faversham, who attended the patient, and to Mr. C. L. Alwork, of Maidstone, who gave me the breech-piece concerned in it. The man, a farm-labourer, by name Rickwood, was wounded on June 6, 1833, and remained at work from the time the wound healed. For some days previously to the escape of the breech-piece, he had experienced sensations as if a piece of bone were coming away; but as soon as the escape occurred he felt well, and went to his work as usual. About three years subsequently he was suddenly seized with a rigor, which was shortly followed by coma, and in this state he continued till his death, which occurred on June 2, 1860, the second day from the seizure. A post-mortem examination was made by Mr. W. N. Spong, of Faversham, but the account of it furnished to me was very meagre. There was loss of substance in the portion of the brain that rests upon the cribriform plate of the æthmoid bone, and this accounted for the fact that he had lost all sense of smell from the time of the accident. The cause of the comatose symptoms does not appear to have been discovered. Some bone near the seat of injury was in a

diseased condition. Three pieces of bone were removed at the time of the accident, but Mr. Alwork informed me there was no exfoliation subsequently, though there was at times discharge of fetid pus from the nostrils. The man constantly complained of headache, and frequently exhibited irritability of temper. The case is probably unique as regards the lodgement of such a heavy and irregularly shaped foreign body for so long a time in the face without detection. Excepting that no abscess appears to have been found, *post mortem*, in Rickwood's case, the condition of the injured parts probably resembled that found in Lieut. Fretz's case. In the latter 'a small abscess was discovered in the anterior lobe of the right hemisphere of the brain. The bottom of the cyst rested on the frontal orbitar plate, and was connected with a dense membrane, which supplied the place of a triangular deficiency in the cribriform plate of the æthmoid bone. The crista galli remained, but was displaced and loosened. The cavity containing the iron appeared to be formed by the æthmoid and sphenoid cells, their internal bony structure having been absorbed. The position of the iron was nearly perpendicular, parts of it projecting into the mouth. It was easily removed. The opening through the palate admitted the forefinger up to the second joint. The back and lower part of the septum narium were destroyed, and there was an opening in the upper part through which the screw passed.' (Op. supra cit. p. 765). From some original documents concerning Fretz's case in my possession it appears that his mental faculties remained unimpaired from the date of his wound to the time of his death. Rickwood's condition was similar in this respect.

Lodgement of pieces of iron in the face, note 19, *page* 166.

The history of Dr. Keith's case will be found in the *Medical Times and Gazette* of October 23, 1858. A side and front sketch of the breech, which was 2¼ inches long, accompanies the history. Dr. Fraser's case is published in the *Edin. Medical Journal* for July 1856, p. 247.

Note 20, *page* 167.—*Amer. Med. Times*, 1863, vol. ii. p. 288.

Neglect of proper exploration of gunshot wounds, note 21, *page* 168.

Laurent, the author of the life of Baron Percy, has related this case, and it is one which conveys a lesson that is worth repeating. An aide-de-camp was wounded in the mouth by a piece of shell. The front teeth were broken away from the lower jaw. Much swelling quickly followed the injury. A surgeon of high grade, or, as Percy designates him, a medical officer, who was unfortunately superior *only* in grade, saw the patient, and, without troubling himself to make a proper exploration, flippantly asserted that the wound was nothing, and would only cost him a fresh set of teeth. As the effects of the wound became more grave, another surgeon was called to see the wounded officer. Putting a finger into the mouth, and making the requisite examination, he at once felt a fragment of iron lodged there, and removed it. It weighed several ounces. But the discovery was too late—the patient died, suffocated from extension of swelling to the neck. The carelessness of the surgeon who had first seen the patient, and the inconsiderate manner in which he had spoken of the wound became known to the soldiers of the army, and they conferred on him an ironical nickname 'Père la Grenade,' which caused the occurrence to be associated with him ever afterwards.

Concealment of foreign bodies, note 22, *page* 169.

Chenu, 'Campagne d'Italie,' vol. ii. p. 299.

Note 23, *page* 170.—Chenu, Op. cit. p. 300.

Multiple wounds of internal organs, note 24, *page* 175.

This case is described in my article on gunshot wounds in the first edition of Holmes' 'System of Surgery,' which was reprinted in the United States during

the civil war, and was issued for use in the army by the U.S. Hospital Department without the slightest regard or remuneration to the publisher to whom it belonged. Dr. Otis in his 'History of the War of the Rebellion,' surg. vol. part ii. p. 70, refers to the case, and prefers to say it was 'observed by Alexander in the Crimea.' But it was not observed by him, as he was not one of those who were present at the post-mortem examination. Dr. Alexander was the principal medical officer of the Light Division in which the 19th Regiment was; and I, as surgeon of the regiment, reported the case to him in due course, and he in turn mentioned it in a letter to Mr. Guthrie.

I have presented a copy of the American reprint of my article on gunshot wounds, with the United States' Hospital Department stamp upon it, to the Medical Staff Library at Netley. The little book in question was not only distributed from the surgeon-general's office at Washington, but was printed as one of the articles in the 'Standard Supply tables' of military hospitals. I should not have referred to this fact, were it not that a list, purporting to be a complete one, of the works and articles on gunshot wounds available for reference in the U. States at the time of the war is given in the first part of the "Surgical History of the War of the Rebellion,' and mention of this particular one, which was so generally circulated in the U.S. hospitals, is altogether omitted.

Multiple wounds, note 25, *page* 176.

'Army Medical Reports,' vol. vii. p. 473.

Note 26, *page* 177.—'Medical and Surgical History of the Crimean War,' vol. ii. p. 262. The animus with which these lance and bayonet stabs are inflicted on men already suffering from gunshot wounds is well shown in an incident of the touching narrative by Col. Ponsonby of his multiple wounds and injuries, and multiplied sufferings as he lay on the field of Waterloo: 'Recovering, I raised myself a little to look round, being at that time, I believe, in a condition to get up and run away, when a Lancer, passing by, cried out, "Tu n'es pas mort, coquin!" and struck his lance through my back. My head dropped, the blood gushed into my mouth, a difficulty of breathing came on, and I thought all was over' (from a quotation by Chaplain-General G. R. Gleig in his 'Story of the Battle of Waterloo,' Lond. 1847, p. 200). Rage, unreflecting excitement, forgetfulness that the actor's own condition may shortly be the same as that of his fallen foe, the dreadful callousness to suffering and disregard of life that habits of fighting engender in so many men, and a feeling, perhaps, that the greater number of enemies that are killed the greater one's own security, all conduce to occasional heartless infliction of such aggravated suffering.

Note 27, *page* 178.—'Surgical History of Crimean War,' vol. ii. p. 330. The patient referred to in the text was discharged from the service at Chatham on December 20, 1855, all his wounds being then healed.

Multiple amputations from gunshot wounds, note 28, *page* 178.

'What we observed at the Seat of War in 1870,' by C. Orton and W. D. Spanton, Lond., 1871, p. 11.

SECTION V.

AIDS TO DIAGNOSIS OF GUNSHOT INJURIES.

Evidence furnished by clothes, note 1, *page* 182.

'A Treatise on Gunshot Wounds, &c.,' by G. T. Guthrie, Lond., 1820, p. 20; Hennen, 'Prin. of Mil. Surgery,' Lond., 1829, p. 36; Jobert De Lamballe, 'Plaies d'Armes à feu,' Paris, 1833, p. 32.

Note 2, *page* 183.—Marshall, 'On the Enlisting, Discharging, and Pensioning of Soldiers,' Edin., 1839, p. 141.

Evidence furnished by hair, note 3, *page* 189.

For a complete history of this case, see *Amer. Journal of the Med. Sciences*, vol. cxxiv., Oct., 1871, p. 385.

Evidence furnished by projectiles, note 4, *page* 190.

'Cat. of Museum of Mil. Surgery,' Netley, appendix, Spec. No. 609 c.

Note 5, *page* 192.—For a full history of this case, see the *Lancet*, vol. i. for 1855, p. 607; and 'Guy's Hosp. Reports,' 3rd Series, vol. v., 1859, p. 173.

SECTION VI.

SECONDARY COMPLICATIONS OF GUNSHOT INJURIES.

Gangrene, note 1, *page* 202.

For a very complete and excellent account of the gangrene of cold and debility, and of frost-bite, as they occurred among the British troops in the Crimea, see the summary of Dr. Hanbury in the 2nd volume of the 'Official Medical and Surgical History of the War,' sect. viii. p. 187 to p. 193; see also Return A. in the same volume, p. 251, showing the monthly admissions into hospital and deaths from disease and injury in the army of the East.

Note 2, *page* 203.—'Report on the Pathology of the Diseases of the Army in the East,' Lond., 1856, p. 105. Dr. Lyons was sent by Lord Panmure in April, 1855, to conduct pathological researches in the hospitals attached to the army in the East. Dr. Lyons' researches were chiefly pursued in the Crimea, while Dr. Aitken, who was with him as First Assistant, conducted the investigations at Scutari.

Note 3, *page* 204.—Op. cit., p. 275.

Secondary hæmorrhage, note 4, *page* 209.

'Report of Obs. in the Brit. Mil. Hosp. in Belgium,' &c., by J. Thomson, &c., Edin., 1816, p. 47.

Note 5, *page* 210.—Guthrie, 'Commentaries on the Surgery of the War in Portugal,' &c., Lond., 1853, p. 203.

Maggots in wounds, note 6, *page* 213.

'Med. and Surg. Hist. of War against Russia,' vol. ii., p. 274.

Note 7, *page* 214.—*Indian Annals of Med. Science*, No. x., Calcutta, July 1858, p. 401.

Note 8, *page* 215.—'Mém. de Chir. Mil.,' &c., Larrey, Paris, 1812, tome i., p. 311.

Hospital gangrene, note 9, *page* 216.

'Commentaries on the Surgery of the War in Portugal,' &c., by G. T. Guthrie, F.R.S., Lond., 1853, p. 169.

Note 10, *page* 216.—Guthrie, op. cit., p. 165.

Note 11, *page* 218.—'Notes on the Surgery of the War in the Crimea,' &c., by G. H. B. Macleod, M.D., Lond., 1858, p. 165.

Note 12, *page* 218.—'Traité de Chirurgie d'Armée,' par L. Legouest, Paris, 1872, p. 650.

Note 13, *page* 219.—*Madras Quarterly Journal of Medical Science*, July 1, 1860, p. 22, &c.

Note 14, *page* 219.—'Principles of Military Surgery,' by John Hennen, M.D., Lond., 1829, pp. 217–220.

Note 15, *page* 221.—'Observations on Phagedæna Gangrænosa,' by H. Home Blackadder, surgeon, Edin., 1818, p. 39.

Note 16, *page* 222.—Guthrie, op. cit., p. 158.

Note 17, *page* 224.—Blackadder, op. cit., p. 43.

Note 18, *page* 224.—Legouest, op. cit., p. 651.

Note 19, *page* 224.—'Outlines of Military Surgery,' by Sir G. Ballingall, M.D., 2nd edit., Edin., 1838, p. 165.

Note 20, *page* 225.—'A System of Surgery,' &c., Edited by Holmes, Lond., 1870, vol. i., p. 164.

Note 21, *page* 225.—Mr. Barker's paper is published in the *Medical Press and Circular* of March 19, 1873, p. 243.

Note 22, *page* 225.—'Experimentelle Beiträge zur Lehre von der Embolie,' Von Prof. Dr. P. L. Panum in Kiel, in Virchow's 'Archiv für Path. Anat. und Phys.,' vol. xxv., Berlin, 1862, footnote p. 441.

Note 23, *page* 226.—Hennen, op. cit., p. 235. Quoted from a paper by Prof. Brugmans.

Note 24, *page* 226.—Blackadder, op. cit., pp. 46–47.

Note 25, *page* 227.—'Guerre de 1870–71,' par le Dr. Chenu, Paris, 1874, p. 303.

Note 26, *page* 228.—Hennen, op. cit., p. 241.

Pyæmia, note 27, *page* 231.

'Very strange instances of translation are given to us; it has been supposed that pus already formed has been translated to another part of the body, deposited there in the form of an abscess, and then discharged. This is absolutely impossible.'—The Works of John Hunter, Edited by Palmer, Lond., 1837, vol. iii., p. 395.

Tetanus, note 28, *page* 241.

'Obs. on the Dis. of Seamen,' by Gilbert Blane, M.D., Lond., 1789, p. 519. From the account given, it appears 810 men were wounded in the actions of April 1782, of whom 266 were killed outright, 67 died of their wounds on board, and 21 in hospital on shore.

Note 29, *page* 241.—'Medico-Chirurgical Trans.,' vol vi., p. 449.

Note 30, *page* 241.—Ballingall's 'Outlines of Military Surgery,' Edin., 1838, p. 257.

Note 31, *page* 242.—'Communication de M. Roux à l'Académie Nat. de Méd. Séance de 1er Août, 1848.'

Note 32, *page* 242.—'Official Surgical History,' p. 284. Two other cases occurred in the field, one after frost-bite, the other probably idiopathic. There were also five cases at Scutari during the winter of 1854–55, three among the wounded from the Crimea, one in a patient suffering from dysentery and frost-bite, and one idiopathic. A sixth case occurred in England. It followed amputation for diseased bone consequent on frost-bite in a Crimean invalid. There were thus twenty-nine cases of tetanus from all causes among the officers and men who were engaged in the military operations against Russia in 1854–56.

Note 33, *page* 242.—'Relation Méd.-Chir. de la Campagne d'Orient,' par le Dr. G. Scrive, Paris, 1857, pp. 349, 448, and 460. Dr. Chenu has not given a table of cases of tetanus in his 'History of the Crimean War.'

Note 34, *page* 242.—'Kriegschirurgie,' N. Pirogoff, p. 928.

Note 35, *page* 242.—'Campagne d'Italie,' par le Dr. Chenu, Paris, 1869, tome ii., p. 396. Numerous reports on tetanus by French surgeons, as observed in the Italian War, with illustrative cases of much interest, are quoted by Dr. Chenu.

Note 36, *page* 242.—Demme, 'Algemeine Chir. der Kriegswunden in den Norditalienischen Hospitalern, von 1859.' Würzburg, 1861, pp. 146-156, and Appendix, p. 283.

Note 37, *page* 243.—'Notes on the Surgery of the Indian Campaign of 1857-58,' by J. Brown, M.D., Bengal Med. Service, in the *Indian Lancet*, 15th Dec., 1860, p. 376.

Note 38, *page* 245.—'Recueil de Mém. de Méd. et Chir. Mil.,' tome v., 1861, p. 392.

Note 39, *page* 246.—'Med. Chir. Trans.,' vol. iv., p. 48. 'Case of wound of the radial nerve.'

Note 40, *page* 247.—'Injuries of Nerves,' by S. Weir Mitchell, M.D., Phil., 1872, p. 147.

Note 41, *page* 247.—'Mém. de Chir. Mil.,' &c., par D. J. Larrey, Paris, 1812, tome iii., p. 292.

Note 42, *page* 247.—Larrey, op. cit., tome iii., p. 286.

Note 43, *page* 247.—Circ., No. vi., W.D., Surg.-General's Office, Washington, 1st Nov., 1865.

Note 44, *page* 247.—'Guerre de 1870-71,' Chenu, tome i. pp. 476-478.

Note 45, *page* 248.—Hammond, 'Diseases of the Nervous System,' New York, 1871, p. 534.

Note 46, *page* 250.—'Holmes's System of Surgery,' 2nd edit., vol. i., p. 319.

Note 47, *page* 252.—'Med. Chir. Transactions,' vol. vii., p. 465.

Note 48, *page* 252.—Larrey, Op. cit., tome i., p. 255, et tome iii., p. 286.

Note 49, *page* 252.—'Hennen's Mil. Surgery,' Lond., 1829, p. 249.

Note 50, *page* 253.—'Glasgow Medical Journal,' No. iv., Jan. 1851.

Note 51, *page* 253.—'Med. Chir. Trans.,' vol. xviii. 'On the pathology of tetanus.'

Traumatic delirium, note 52, *page* 262.

'Aperçu historique, statistique, et clinique sur le service des Ambulances, &c., pendant la guerre de 1870-71,' par le Dr. J. C. Chenu, Paris, 1871, tome i., p. 475.

SECTION VII.

ULTIMATE SEQUENCES OF GUNSHOT INJURIES.

Remote effects of lodged substances, note 1, *page* 265.

'Hunter's Works,' edit. 1794; 'The ulcerative inflammation,' p. 450.

Note 2, *page* 268.—'Handbuch der Kriegs-Chir.,' &c., von J. Neudörfer, Zweite Halfte, Leipzig, 1869, p. 590-591.

Note 3, page 268.—In a case of lung wound related in the *Journal of the Medical Sciences* for 1845, by Dr. Houston, a sinus existed for twenty-five years, and, after death, a linen fragment, 'coiled up in the shape of a silkworm,' two and a half inches long by two wide, was found in a cavity connected with it.

Remote effects of gunshot wounds, note 4, page 281.

'System of Surgery,' edited by Holmes, &c., Lond., 1870, vol ii., p. 226.

Note 5, page 288.—An account of this case is published by Dr. W. J. Rundle, Major B.'s medical attendant, in the *Medical Times and Gazette*, 1866, vol. i., p. 306. A sketch of the bullet and parts implicated in the obstruction, by Dr. J. Ward Cousins, accompanies it.

SECTION VIII.

TREATMENT OF GUNSHOT INJURIES.

Provisional treatment, note 1, page 297.

Lancet, May 6, 1871, p. 631. Dr. Wolseley has been since led to believe that the Rangoon oil is sufficiently antiseptic without the addition of carbolic acid. The Rangoon oil is a mineral oil containing paraffin.

Clearing fields of action, note 2, page 300.

There is reason to fear that some men in a comatose condition from injuries to the head, others suffering from collapse after hæmorrhage, or from profound shock after severe wounds, are occasionally buried after battles on the supposition that they are dead. It has been sufficiently established that any one of the usual signs of death, excepting decomposition, may be present and life yet be not extinct. It has also been shown by Professor Rosenthal, of Vienna, and others that the only test, short of decomposition, which shows death to have taken place with absolute certainty is the absence of electro-muscular contractility on the application of a faradic current. The means of applying this test may exist in general hospitals, but cannot be expected to be found on fields of battle. In its absence the fact of the complete cessation of the heart's action, and the presence of some of the other usual signs of death, can only be properly determined by a medical officer, or, at least, can be more surely established by him than by a non-professional observer.

Field tourniquets, note 3, page 303.

Dr. D. Foulis' Improved Elastic Tourniquet. This contrivance acts on the same principle as the temporary expedients for checking bleeding explained in the text, but would be even more dangerous if applied to general use in the field. It was introduced early in the year 1875. It consists of a solid vulcanised india-rubber cord. The two ends, after the cord has been put on the stretch, can be quickly and firmly secured by a very ingenious catch which is attached to it. They fix themselves in the catch by their own elasticity. This instrument answers admirably as an elastic band for keeping back the afflux of blood to a limb which has been previously prepared for the performance of a bloodless operation on a patient in a state of anaesthesia, for the whole limb is firmly constricted by it, and the circulation is completely stopped. But the very qualities which make it answer this purpose obviously render it dangerous as a field tourniquet. Moreover, the pain caused by it in patients with their senses unblunted quickly becomes intolerable. The pressure is the same at every point

of the circumference of the limb, and is necessarily very great, from the manner in which the ends of the india-rubber are secured in the catch; while it does not admit even of the amount of adjustment which can be obtained, by a little management, in the common pad and buckle tourniquet.

Note 4, page 304.—Dr. Lee, in his pamphlet on the uses and applications of Lambert's Elastic Tourniquet, states he was informed 'by a brigade-surgeon, who was at Bull's Run, where more than two thousand were wounded, that the use of the field tourniquet was so frequently followed by mortification and the loss of the limb, that he had come to the conclusion it was far safer to leave the wounded to nature, without any attempts to arrest the flow of blood, than to depend upon the common army tourniquet.' He also quotes the following passage to the same purport from Dr. McClellan's 'Princ. and Prac. of Surgery,' Phil., 1848: 'The usual practice on the field is to check hæmorrhage immediately by the application of a tourniquet, or some extemporaneous substitute, which answers a temporary purpose at the expense of a most injurious congestion of the wound and all the parts below. In hot weather especially, vascular engorgement, tumultuous excitement, and mortification are insured by such a rude and mechanical instrument. The surgeon would, in general, do vastly better by leaving the wound in the hands of nature under such circumstances.'

Winged tourniquets, note 5, *page* 304.

See a pamphlet entitled, 'A description of the newly-invented Elastic Tourniquet, for the use of armies, &c.' by C. A. Lee, M.D., New York, 1862.

Note 6, *page* 306.—A drawing of Mott's Winged Tourniquet may be seen in Dr. Mott's essay on 'Hæmorrhage,' at page 403 of the vol. of 'Mil. Med. and Surg. Essays, prepared for the U.S. San. Commission,' edited by W. A. Hammond, &c., Phil. 1864; also in the 'Surgeon's Pocket Book,' by Porter, Lond., 1875, page 204.

Note 7, *page* 308.—See a description by Surgeon-Major Moffitt, of his winged screw tourniquet, in the *Brit. Med. Journal*, for Jan. 1874, page 16.

Distribution of tourniquets, note 8, *page* 308.

Dr. Mott advocated the general introduction of tourniquets among troops in his essay on 'Hæmorrhage,' not only on account of its advantage in stopping loss of blood, but also on account of the moral courage and confidence which the possession of the instrument would give to soldiers. The arguments of this distinguished surgeon do not, however, appear to me to overrule the practical difficulties and inconveniences which would attend such a general distribution of tourniquets. Several surgeons of high position in the United States, when testifying to the merits of Lambert's tourniquet, express the view that every soldier should have one as a 'life preserver.'

Digital control of hæmorrhage, note 9, *page* 310.

Demme, op. cit., page 110. Among others, Dr. Demme particularises the case of a young Austrian soldier, who was wounded at Melegnano in the left thigh, during the attack of the Zouaves. Feeling the warm blood flowing down his leg, he tore open his trouser, introduced his left thumb into the wound, and kept it in that position for four hours. At the ambulance, the femoral artery was found to have been perforated, one inch below the origin of the profunda branch, and a double ligature was then applied at the seat of injury. The wounded man dwelt with justifiable pride on the coolness and presence of mind which he had displayed in carrying out this means of self-preservation.

Exploration of gunshot wounds, note 10, *page* 316.

The rule, to place the patient in the same position he was in when wounded, was followed before fire-arms were invented. It was the established practice in

the extraction of arrows, darts, and other similar weapons, and was simply continued when shot from fire-arms had to be taken out of the body. Ambrose Paré, in the short account which he gives of his service at the siege of Perpignan, in 1545, mentions a case in which he gained great credit by attention to this rule. M. de Brissac, grand master of the artillery, was wounded, on the occasion of a sortie from the town, by a bullet in the shoulder. Lying on a bed in his tent, he was examined by several of the most eminent surgeons with the army, and they, being unable to find any trace of the bullet, declared it had passed into his chest. Having known Paré before, M. de Brissac sent for him. Paré made him get up from his bed, and place himself in the position in which he was when he was hit. This at once gave Paré the cue. Following the direction of the wound with his hand as the patient stood in position, he presently came upon a little swelling under the scapula, determined this to be the site of lodgement, and from it shortly extracted the bullet.

Digital exploration of gunshot wounds, note 11, page 322.

Some eminent surgeons have objected to exploring gunshot wounds by the finger for establishing an early diagnosis, but I do not think they do so on sufficient grounds. That the evil effects, described in the text, of abstaining from exploring wounds in the way mentioned are not imaginary, I will quote a portion of a letter, written to me by a very experienced surgeon in 1865, during the last war in New Zealand :—'Some cases have shown how extremely necessary is a careful examination by the finger of all wounds on the field. I may especially mention the shoulder-joint cases. These were first seen by inexperienced assistant-surgeons, who neglected examining them with the finger, and, consequently, with the probe were not aware of the real nature of the injuries. The wounds were not diagnosed, as affecting the joints, at the very period above all others when it was easy to do so. Days passed on before it was possible to decide from the great swelling, inflammation and infiltration of the tissues, what was the real nature of the damage done. In some of the cases in which an examination was tried, it had to be desisted from, owing to its causing extreme pain and suffering. After being from five to six days in hospital, the peculiar character and odour of the discharge gave indubitable indications of the exact nature of these wounds. The case of ——, also, well exemplifies what I have remarked. He was wounded in the shoulder-joint, no digital examination was made; and, being under another surgeon, I did not examine the wound. I was repeatedly assured the joint was safe, although I never agreed to this; particularly on account of the nature of the discharge. After three weeks of intense suffering, and serious constitutional disturbance, I urged the propriety of placing the patient under chloroform, and thoroughly exploring the wound. This being done, not only was fracture found to be present, but the greater portion of the head of the humerus was dislocated back on the scapula. You may picture to yourself the effects of this on a patient of an irritable and highly strumous constitution; it nearly cost him his life. Had all these cases been at once recognised on the field, primary operations would certainly have been resorted to, with a most considerable reduction in the constitutional suffering, and bad after-effects to the patients.

'In ——'s case, too, it was self-evident how very different would have been the final results in a man of his constitution, had a primary operation been practised; and the extreme severity of the injury would have settled the necessity of the procedure, had it been diagnosed at once, by examination with the finger, after the receipt of the wound.'

I have quoted this passage at length, as it so strongly illustrates the necessity for establishing a correct diagnosis of penetrating gunshot wounds at the earliest opportunity, by digital exploration. If further evidence be necessary for impressing the importance of this point of practice on the minds of young field surgeons, I may mention that on asking my able friend, Dr. Frank, who was actively engaged in volunteer ambulance work throughout the late Franco-

German War, what was the most important lesson this farther experience in the field had taught him; his reply was, 'I have more than ever seen the ill-results of neglecting the early exploration of wounds, and the good results to patients and surgeons when the diagnosis of them had been thoroughly established at the first examination.'

Extraction of foreign bodies, note 12, *page* 331.

'Histoire de l'état et du progrès de la Chir. Mil. en France, &c,' par M. Briot, Besançon, 1817, p. 97.

Note 13, *page* 332.—Legouest. 'Traité de Chir. d'Armée,' Paris, 1872, p. 411.

Note 14, *page* 332.—Circ. No. 3, 1871, p. 87.

Dressings for gunshot wounds, note 15, *page* 338.

Among the specimens of materials for dressing wounds in the Museum of Military Surgery at Netley, are the following descriptions of oakum:—

No. 725. Surgeon's tow, carbolised. Fibres of variable thickness, uneven, and moderately rough. Readily separates into very short pieces. Very little odour of tar. Feels slightly greasy between the fingers.

No. 726. Sample of oakum used for dressing wounds at Paris during the siege of 1870-71. Fibres very coarse, rough, and of variable thickness. Tarry odour strong.

No. 727. Tenax. Specially prepared for surgical purposes. Fibres coarse, but not so much so as No. 726. Contains many short, harsh pieces among it. Breaks up readily under pressure, and numerous dusty small portions drop from it.

No. 728. Calvert's carbolised tow. Fibres long, hair-like, even in thickness, free from knots and hard lumps, and reddish brown in colour. They present a silk-like glossy appearance. The tarry odour is very strong. It feels greasy to the touch. This carbolised tow wants the springiness that characterises the oakum made from ropes.

Antiseptic dressings, note 16, *page* 340.

The following are Professor Lister's directions:—'Wash the wound thoroughly, and also the surrounding skin, with a saturated solution of crystallised carbolic (phenic) acid in water, one part of the acid to twenty of water, introducing the fluid by means of a syringe, and manipulating the parts freely so as to cause the lotion to penetrate into all the interstices of the wound, and at the same time squeeze out such clots of blood as it may contain. The fluid should be introduced repeatedly to insure its thorough penetration. Tie any bleeding vessels with properly prepared antiseptic catgut, cutting off the ends of the thread near the knot. If the surgeon does not possess this article, the arteries should, if possible, be secured by torsion; but for the sake of cases in which a ligature would be absolutely indispensable, some silk or linen thread should be kept steeping in a strong oily solution of carbolic acid, or, if very fine silk be used, it may be rendered antiseptic by steeping for a few minutes in the watery solution. When silk or linen is employed, the ends of the ligatures should be left projecting at the wound. While the antiseptic lotion is in the wound, extract if possible any foreign material that may have been introduced, such as a bullet or a portion of the patient's clothes; and if any spicula of bone exist entirely detached from the soft parts, remove such as can be readily reached, disregarding those which are of very small size or inconvenient of access. Then place upon the wound two or three layers of oiled-silk smeared on both sides with a solution of carbolic acid in five parts of any of the fixed oils—olive, almond, linseed, &c.—the oiled-silk being made large enough to cover the raw surface completely and slightly overlap the surrounding skin. Next apply, without loss of time, lint, charpie, or cloth (linen or cotton), well steeped in the oily solution of the acid, the cloth or lint being folded sufficiently to produce a

layer at least a quarter of an inch in thickness, and extending a considerable distance, say three inches, beyond the oiled-silk in all directions, the outer layer being made somewhat larger than the rest, so that the margin of the mass of cloth may be thin. Cover the oily cloth with a piece of thin gutta-percha tissue sufficiently large to overlap it on all sides by an inch or more, and retain it securely in position by a roller steeped in the antiseptic oil. Round this again wrap a still larger piece of folded cloth, say a folded towel, also steeped in the oily solution of carbolic acid, and cover it with a piece of oiled-silk or gutta-percha.'—'A Method of Antiseptic Treatment Applicable to Wounded Soldiers in the Present War,' by J. Lister, F.R.S., &c.

Antiseptic applications, note 17, *page* 341.

'On the Treatment of Gunshot Wounds by Chloride of Zinc,' by Wm. R. Smart, M.D., C.B., Ins. Gen. R.N., *Brit. Med. Journal*, Oct. 22, 1870, p. 434. See also a paper in the *Lancet*, Oct. 1870, p. 562, by Dr. Smart.

Note 18, *page* 341.—'On the Treatment of Gunshot Wounds by Chloride of Zinc,' by Mr. C. de Morgan, F.R.S., &c., in the *Brit. Med. Journal*, Oct. 15, 1870, p. 410. See also a communication 'On the Use of Chloride of Zinc,' in the *Brit. and For. Med. Chir. Review*, for Jan. 1866, p. 201.

Note 19, *page* 341.—Die antiseptische Wundbehandlung in der Kriegschirurgie von Dr. F. Esmarch, &c. Vortrag, gehalten in der ersten Sitzung des Congresses am 19 April, 1876. Trowitzsch und Sohn, Berlin.

Drainage tubes, note 20, *page* 342.

Dr. F. Christot has published reports of a considerable number of gunshot wounds in which the use of drainage tubes formed a special part of the treatment, in his pamphlet, 'Drainage dans les Plaies par Armes de Guerre,' Paris, Baillière, 1871, pp. 64, &c. He extols the drainage system very highly, as leading to a more speedy cure in many cases, and as 'a valuable means of warding off the accidents which are apt to follow gunshot wounds of soft parts. It gives happy results in cases of long and narrow, muscular, and aponeurotic wounds, when they are complicated with diffuse inflammation and extensive suppuration. Owing to the opportunity of flow which it affords to the pus and septic fluids of all kinds, it constitutes a good means of checking traumatic fever and preventing or dispelling septicæmia. Its application seems especially advantageous in cases where the inflammatory phenomena have been excited by the prolonged presence of foreign bodies in the tissues—projectiles, bits of clothing, splinters, &c.'

Drainage tubes, note 21, *page* 343.

A full description of Mr. Ellis' wire drainage tubes may be found in the *Lancet* of the 24th of July, 1869, p. 115. Sir J. Paget has given the weight of his high authority in their favour. He ascribes to them the following advantages:—1. They can be placed in sinuses of very small diameter, and with equal advantage whether the sinus has one or more openings. 2. Their bore is not diminished by bending them to any angle. 3. They cannot be flattened or shut up by contraction of the orifice of the sinus. 4. They can be inserted with great facility. 5. They can be worn for any length of time in fit cases without causing irritation. 6. They are cleanly and excite no decomposition in pus or other fluids.

Dressings used in foreign hospitals, note 22, *page* 347.

'Lessons on Hygiene and Surgery from the Franco-Prussian War,' by C. A. Gordon, M.D., C.B., &c., London, 1873, p. 124.

Treatment by hermetically sealing, note 23, *page* 348.

Dr. J. Julian Chisolm, Professor of Surgery in the Medical College of South Carolina, and author of a very handy and concise 'Manual of Military Surgery

for the Use of Surgeons in the Confederate States' Army.' This work, though comparatively of small size (3rd edit., small 8vo., 529 pp.), contained an epitome of information on military surgery, military hygiene, and twenty-six plates of the principal surgical operations, with a descriptive text.

Treatment by pneumatic occlusion, note 24, page 349.

An account of the treatment of wounds by 'Pneumatic Occlusion' has been published by Dr. Jules Guérin, in the form of a pamphlet, but I have not got it at hand to refer to. See also a fresh note on the treatment of wounds by 'Pneumatic Occlusion,' read at the Paris Academy of Medicine, 9th August, 1870, by Dr. Guérin. There had been previous discussion on the same subject at the Academy, which had lasted some months. Dr. Guérin treated cases of gunshot wounds by his method during the siege of Paris, and according to Dr. Guérin's statement, as reported by Surgeon-General C. Gordon, 'in nineteen cases of grave wounds of the limbs, some through the larger joints, there was only one death. The patients who were thus treated were said to have escaped pyæmia, although that disease was extensively prevalent in other rooms of the same building.'—'Report on Military Hygiene and Surgery during the Siege of Paris, 1870–71,' by C. A. Gordon, M.D., C.B., &c., p. 53.

Treatment by cotton-wool, note 25, page 350.

'A New Method of Treating Wounds (Gruby's system),' &c., by C. F. Stuart Macdowell, Surgeon, Indian Army, &c., London, Churchill, 1871, pp. 35.

Exploring instruments, note 26, page 362.

Chemical reagents are not altogether abandoned for this purpose. M. Desnenx, in 1872, suggested a plan for adoption which he had used in three cases with success. The end of a flexible rod is covered with a piece of lint steeped in dilute nitric acid, which is pressed for a few minutes against the supposed foreign body. On being withdrawn it is applied to a solution of iodide of potassium. If lead be present, the yellow colour of iodide of lead will appear. —*Bull. de l'Acad. de Méd. de Paris*, 16th July, 1872.

Note 27, page 365.—*Gazette des Hôpitaux*, 29 Nov., 1862, p. 553. A complete account of the use of electricity for the discovery of projectiles lodged in the body will be found in chap iv. sect. 3 of the valuable work on 'Medical Electricity, &c.,' by Julius Althaus, M.D., 3rd edit., London, 1873.

Note 28, page 365.—'Storia della ferita del Generale Garibaldi, toccata il 29 Agosto, 1862, in Aspromonte.' Compilata dal Dottor Giuseppe Basile, &c., &c. Palermo, 1863, p. 23.

Note 29, page 367.—The projectiles named in the text are preserved in the Museum of Military Surgery, at Netley.

Note 30, page 367.—See the 'Wiener Medizinische Wochenschrift' of 24 June, 1870.

Bullet extractors, note 31, page 368.

The description of bullet extractors given in the text agrees with the specimens of them which form part of the collection in the Mus. of Mil. Surgery at Netley.

Note 32, page 374.—See a description of 'A newly invented instrument for the extraction of balls from gunshot wounds, &c.,' by J. B. Raspini, London, 1813, in 'Medical Tracts,' vol. x.

Percy's Tribulcon, note 33, page 379.—Drawings of this instrument of full size, as well as a description of the manner of using it, may be seen in Percy's well-known work, 'Manuel du Chirurgien d'Armée,' Paris, 1792.

Note 34, page 380.—See a pamphlet entitled 'Description d'un nouveau

Modèle de Tire-balle dont on peut construire sept différents instruments, &c., par C. de Mouij, Méd. Militaire de 2e classe de l'armée des Pays Bas,' Maestricht, 1866. It includes fifteen drawings, showing the manner of adapting the instrument to the various uses for which it has been designed. A specimen of Dr. Mouij's instrument is in the Mus. of Mil. Surg. at Netley.

Constitutional treatment, note 35, page 382.

The pernicious influence on the British troops of the three months' residence in Bulgaria has been fully unfolded by my colleague Professor Aitken, in a paper which will be found in vol. xl. of the 'Medico.-Chirurgical Transactions.' In it he has shown that the percentage of deaths in the same diseases was invariably greater, in a marked degree, during the first seven months of the Crimean War among the troops who had resided in Bulgaria, than it was among the troops who came direct to the Crimea from England or elsewhere. The same results were observed in the cases of injuries. The ratios of deaths to the total admissions for injuries were 19·1 per cent. among those men who had formed part of the force in Bulgaria; but only 13·7 per cent. among those who had served in the Crimea only. The ratios of invaliding to the admissions for injuries were 45·1 per cent. among those who had been in Bulgaria: only 20·4 per cent. among those who had served in the Crimea only. Dr. Aitken's paper is well worthy of attentive study by all medical officers who are interested in tracing the causation of disease and mortality among bodies of troops. Those who passed through the three hot and depressing months in Bulgaria, during which the army was quartered in that unhealthy country, will not need to be reminded how important an item in the long list of agents, which made that residence so constitutionally hurtful to the troops, was the unnutritious quality of the rations issued to the men, the unskilful manner in which they were ordinarily cooked, together with the general absence of vegetables and other necessary dietetic adjuncts. Had no other cause for deterioration of bodily health existed, the indigestible diet of the troops in Bulgaria and the deficiency in certain classes of aliment would alone have sufficed for bringing the health standard so low as to render the men prone to any disease that circumstances might favour, and materially to affect the mortality and invaliding results of injuries among them.

Note 36, page 388.—It is never to be forgotten that the study of practical hygiene is as important for surgeons as it is for sanitary officers. The province of practical hygiene is not limited to the preservation of health and to warding off disease; if it were, its interest would be much lessened so far as surgical injuries are concerned. It is equally its province to put men in the best state of preparation for repairing the injuries, and recovering from the diseases to which they, especially soldiers, are liable to be subjected. In proportion as practical hygiene has been attended to, so will the treatment of injuries be simplified, and the death and invaliding rates be lessened; in proportion as it has been neglected, so will the difficulties of treatment be increased, and the death and invaliding rates mount higher. Army medical officers should especially keep themselves in constant familiarity with the science and practice of hygiene as taught in the invaluable work on the subject by my late distinguished colleague Dr. Parkes.

Note 37, page 389.—During the Civil War in the United States, the Volunteer Aid Societies supplied enormous stores of antiscorbutic articles for the use of the sick and wounded in the military hospitals. They consisted of dried apples, prunes, and other fruit; apple preserve, pickled tomatoes, tamarinds, lemons, oranges, lemon juice and lemonade, porter, &c. Such articles are of great value when fresh fruits and vegetables are not procurable. They are far superior, as antiscorbutics, to the dried potatoes and vegetables which are issued in large quantities in Europe and are rarely relished, however prepared, by soldiers.

Treatment of secondary hæmorrhage, note 38, page 399.

'Guthrie's Commentaries,' London, 1853, p. 68.

Treatment of hospital gangrene, note 39, page 404.

'Military Medical and Surgical Essays, prepared for the U.S. Sanitary Commission,' edited by W. A. Hammond, M.D., Surgeon-General U.S. Army, Phil., 1864, p. 85.

Note 40, page 405.—Chenu. 'Guerre de 1870–71.' Tome i. p. 478.

Note 41, page 405.—'Lectures on Inflammation,' by J. Thomson, M.D., &c. 2nd Amer. edit., Phil. 1831, p. 398.

Note 42, page 406.—See 'Observations on Hospital Gangrene, as the disease appeared in the British army during the late war in the Peninsula,' by John Boggie, M.D., Surgeon to Her Majesty's Forces, Edin., 1848.

Note 43, page 406.—'Hennen's Military Surgery,' London, 1829, p. 226.

Treatment of tetanus.

Note 44, page 411.—Chenu. Op. cit., p. 398.

Note 45, page 412.—Chenu. Op. cit., pp. 405, 413.

Note 46, page 413.—Circular No. 6, War Department, Surgeon-General's office, Washington, Nov. 1st, 1865, p. 42.

Note 47, page 413.—'Campagne d'Italie,' Chenu, Tome ii, p. 397.

Note 48, page 414.—'Allgemeine Chirurgie der Kriegswunden nach Erfahrungen in den Norditalienischen Hospitälern, von 1859,' von Dr. H. Demme, Wurzburg. 1861, p. 146, &c.

Note 49, page 414.—'Guerre de 1870–71,' Chenu, Tome 1er, p. 476.

Treatment of erysipelas, note 50, page 419.

'On the treatment of Erysipelatous Inflammation,' in 'Practical Obs. in Surgery, more particularly as regards the Naval and Military Service,' by A. Copland Hutchison, Surgeon, R.N., London, 1826, pp. 110–140.

Treatment of traumatic delirium, note 51, page 421.

Chenu, 'Guerre de 1870–71,' Tome 1er, p. 472.

SECTION IX.

GUNSHOT INJURIES AND FIELD SERVICE.

Army hospital organisation, note 1, page 433.

'Tables showing the details of a Bearer Company and Field-Hospital of an Army Corps,' issued with Army Circulars, dated June, 1877. It is understood that complete regulations will shortly be issued by the Director-General regarding the duties of all medical officers, administrative as well as executive, with an army corps on active service, and also lists of the different kinds of stores forming the equipment of the bearer companies and other field-hospital establishments. It will be important for army medical officers to make themselves familiar with these regulations when they are published.

Note 2, page 433.—No. $\frac{40116}{78}$ 'Tables showing the war strength and composition of an Army Corps,' issued with Army Circulars dated August, 1875.

Note 3, page 433.—See remarks on this subject in a lecture on 'Assistance to the Wounded in Time of War,' delivered May, 1876, by Surgeon S. Moore

Instructor Army Hospital Corps,' and printed in the Journal of the Royal U.S. Institution, vol. xx., No. 88, p. 658.

Regimental bearers, note 4, page 434.

'Journal of the Royal U.S. Institution,' vol xx., 1876, p. 682.

Arm badge of the Prussian auxiliary bearers, note 5, page 434.

As these men only acted in the capacity of bearers during or after battles, while at other times they were engaged in ordinary military duties, it was certainly contrary to the spirit of the Geneva Convention for them to wear the white brassard with the red cross. Numerous complaints of this misapplication of the brassard were made on the French side during the Franco-German War. These allegations led to the following ordinance by the Emperor of Germany :—

'From trusty representations made to us, we command, as a modification of § 7, of "The instructions for the Sanitary Service of the Army in the Field, of April 29, 1869,"—that in future the auxiliary sick-bearers of the troops shall wear on the left upper arm a red band, instead of the white band with a red cross. The War Ministry will carry out the further details of this command.

(Signed) WILLIAM.

'Berlin, June 6, 1872. V. ROON.'

Army hospital corps, note 6, page 439.

An account of this corps, its history, its present organisation, and the course of training undergone by the men composing it, may be found in the following works :—'Treatise on the Transport of Sick and Wounded Troops,' pp. 39–45, for the history and constitution of the corps up to the year 1869; and 'Regulations for the Army Hospital Corps,' issued with Army Circular dated July 1, 1875, for its present constitution and regulations. The manner in which they are instructed to perform their duties in reference to attendance on the sick and wounded in hospital, to first assistance and transport of wounded in the field, and to field-hospitals, are plainly shown in the excellent pocket 'Manual of Instructions for Non-Com. Officers and Men of the Army Hospital Corps,' written by Surgeon-Major A. Moffitt, former Instructor of the Corps, and issued by War Office authority in July, 1875.

Servants to medical officers, note 7, page 442.

The condition of surgeons on general duty in the field has hitherto contrasted unfavourably, as regards personal care and comfort, with that of the surgeons attached to regiments. The latter have had the advantage of a share of the attention which all officers of regiments receive. They have never been in any difficulty as regards servants, so that their personal wants have been properly provided for. Not so with medical officers on general employ. Even in the autumn manœuvres in England they have been usually subjected to much annoyance and discomfort from want of arrangements, or at least of an adequate provision, for the accommodation and rationing of their civil servants. It is hoped that the new organisation of the bearer companies and field-hospitals will remove these difficulties in future.

Field-hospitals, note 8, page 450.

The term 'Flying Hospital' is probably as old as the term 'Flying Artillery.' Dr. Monro, Physician to the Forces, has a chapter on 'Movable, or Flying, Hospitals,' in his work on preserving the health of soldiers, published in 1780.

Field-hospitals with troops on the march, note 9, page 451.

All military details are, of course, omitted that are not necessary to illustrate the positions of the field-hospital establishments. The details may be seen at

p. 171 of that excellent work, 'A Précis of Modern Tactics,' by Major Home, R.E., Lond., 1873.

Hospital ships, note 10, *page* 466.

For a description and plan of the arrangements for accommodating patients in these ships, see vol. i. of 'Army Medical Reports,' for the year 1859, Lond., 1861, p. 337. See the report upon H.M.S. 'Victor Emanuel,' hospital ship, with plans, by Surgeon-Major Bleckley, M.D., C.B., in 'Army Medical Reports,' vol. xv., Lond., 1875, p. 260.

Arrangements on a force quitting England, note 11, *page* 477.

For the manner in which inspections of transports are to be conducted and the particular subjects of inquiry, see the Queen's Regulations and Orders for the Army, Edit. 1873, section 17, 'Movement of Troops by Sea.' For further special sanitary instructions, see 'Sanitary Regulations of the Army Medical Department,' issued with Army Circulars dated December, 1876, as well as the 'Army Medical Regulations for Medical Officers in charge of Troops on Board Ship,' issued with Army Circulars dated October 1, 1876.

Field-hospital organisation, note 12, *page* 487.

'Millingen's Army Medical Officer's Manual,' Lond., 1819, p. 241. It will be seen by reference to this admirable work, that nearly all the improvements which have been introduced of late years into the field medical arrangements of European armies are advocated in it.

Field panniers, note 13, *page* 494.

The result of the experience of the war in the north of China in 1860, led Sir Wm. Muir, the Principal Medical Officer of the Expeditionary Army, to report them to be 'the most useful and portable ever furnished to an army' (Army Medical Department Reports, vol. ii., Lond., 1862, p. 378). Sir Anthony Home, V.C., in his report of the Ashanti campaign, calls them 'the invaluable, the nearly perfect field panniers' (A. M. Dep. Reports for 1873, vol. xv., p. 249).

Field-hospital equipment, note 14, *page* 512.

'Autobiography of Sir J. McGrigor, Bart.,' p. 94.

Hospital tents, note 15, *page* 520.

'Report of the Royal Commissioners,' p. 48.

Field bedsteads, note 16, *page* 521.

'Instructions to Regimental Surgeons for Regulating the Concerns of the Sick,' Appendix No. 11, Lond., 1808.

Substitutes for ambulance stores, note 17, *page* 523.

Larrey. 'Memoires de Chir. Mil. &c.' 'Campagne de Russie,' vol. iv., p. 31.

Note 18, *page* 523.—'Life of Dr. Jackson,' Lond., 1845, p. 34.

Note 19, *page* 523.—'Campagne d'Italie de 1859.' Lettres Medico-Chir. par le Dr. A. Bertherand, Méd. Prin. de 1ere Classe, Paris, 1860, p. 163.

Carriage of stretchers, note 20, *page* 528.

'Army Med. Reports for year 1866,' vol. viii., Lond., 1868, p. 613.

Ambulance transport, note 21, page 544.

For other particulars concerning mule cacolets and mule litters, and directions concerning their use, I may refer to my 'Treatise on the Transport of Sick and Wounded Troops,' Lond., 1869, pp. 272–285. See also a recently published very instructive and interesting 'Report on the Transport of Sick and Wounded by Pack Animals,' by G. A. Otis, U.S. Army, Washington, 1877. This report embodies the experience of many campaigns in which the U.S. troops have been engaged with Indians, in regions inaccessible to wheeled vehicles.

Note 22, page 549.—Many subjects of interest connected with the construction and purposes of the present pattern ambulance sick-transport wagon will be found in the 'Report of the Committee appointed by Sir John Pakington, Secretary of State for War, on April 24, 1868, to enquire into the general question of Hospital Conveyances for the Army.'

Note 23, page 554.—See on this subject 'Studien über den Umbau und die Einrichtung von Guter-waggons zu Sanitäts-waggons, mit 9 Tafeln, Wien, 1875.' Professor Billroth's excellent work 'Über den Transport der Verwundeten und Kranken auf Eisenbahnen im Felde,' Gerold, Wien, 1874, may be consulted on the subject of railway ambulances with advantage. The English reader will find many points on the subject discussed in my work on ambulance transport before cited.

SECTION X.

CLASSIFICATION OF GUNSHOT INJURIES.

Denomination of gunshot injuries, note 1, page 555.

Also 'scloppus.' Persius, in his 5th Satire, censuring a pompous style of declamation, writes 'Nec scloppo tumidas intendis rumpere buccas.' See Delphin edition, Lond., 1786, p. 363. The word appears to have been sometimes written 'Stloppus' or 'Stlopus.'

Note 2, page 556.—The same word is used in modern Latin or Italian, 'Schioppo,' a gun; 'Schioppetto,' a musket; and 'schioppettiere,' a fusilier; being simply modifications of it.

General Classification, note 3, page 556.

A want of uniformity appears to have occurred inadvertently in the nomenclature as regards the equivalent values of the French terms 'Blessure' and 'Plaie.' The word 'blessure' is rightly given as the French equivalent for the order 'Injury,' in local Diseases (see 'Nomenclature,' p. 30), but it will be found that in the subsequent detailed nomenclature of particular injuries, this appreciation of the term is not maintained. Although the general order of 'Injuries' is kept up on the English side, and its division into 'Contusions' and 'Wounds' properly marked, the word 'blessures' is used as equivalent for the latter division, 'wounds,' instead of the word 'plaies,' in various instances (see 'Injuries of the Pelvis, of the Face,' &c.). Indeed, on looking through the list of local injuries, the terms 'plaie' and 'blessure' appear to be used indiscriminately, as if they were of equal value in the French language for an injury, whether without or with solution of continuity in the part injured. I need hardly say that the term 'blessure' alone includes both kinds of injuries; the term 'plaie' being restricted to injury with division or separation of structure.

Note 4, page 559.—The following is the most recent order on this subject:— 'The medical officer attached to a corps, or detachment, will forward to the

principal medical officer, as soon as possible after an action, a nominal return of officers, non-commissioned officers and men, who have received wounds or injuries in battle; in this return the kind of wound received, and its degree of severity, should be described as tersely and as accurately as possible.'—Regs. on Statistical Returns, issued with Army Circular, August 1, 1876, par. 35. Recent changes will cause this duty to devolve on the surgeons in charge of the field-hospitals.

Special classification, note 5, page 561.

Mr. Taylor published his classification, together with some explanatory observations, early in the year 1856, under the title of 'A Classification of Wounds and Injuries received in action, proposed for use in military hospitals, submitted to the Director-General of the Army and Ordnance Medical Departments, and to the Principal Medical Officer with the Army in the Crimea,' by J. R. Taylor, C.B., Deputy-Inspector General, camp near Sebastopol, January 26, 1856.

Note 6, page 562.—The 'Descriptive Numerical Returns of Wounds and Injuries received in Action during the Mutiny in India, &c.,' up to June 30, 1859, are published in 'Notes on the Wounded from the Mutiny in India,' by G. Williamson, M.D., Staff Surgeon, Lond., Churchill, 1859, pp. 5 and 115. These returns are completed up to December 31, 1862, at p. 463, of the 4th vol. of the Army Med. Dep. Reports, in the year 1862, Lond., 1864.

Note 7, page 562.—'The New Zealand War of 1863–65, &c.,' by Inspector-General Mouat, V.C., C.B., vol. vii., Army Med. Dep. Reports for 1865, Lond., 1867, p. 473.

Medical statistics of an army in the field, note 8, page 566.

'A classified return of wounds and injuries received in each action is to be sent on Form N' (see form 1, p. 568), 'as soon as possible, by the surgeon or medical officer in charge to the principal medical officer.'

'A classified return of wounds and injuries of every kind received in action and admitted into hospital is to be made up in form O' (see form 2, page 569), 'and transmitted by the regimental surgeon or medical officer in charge to the principal medical officer, at the conclusion of each week.'—Extracted from 'Army Medical Regulations,' Lond., 1859, pp. 94, 95.

The most recent instructions on this subject will be found in the Army Medical regulations regarding 'Statistical Returns for Troops on Active Service,' promulgated on August 1, 1876.

Special classification, note 9, page 573.

See vol. liv. of the Transactions published by the Royal Med. and Chir. Soc. of London, in 1871. The chief object of this paper was to try and estimate the relative merits of the different plans which had been adopted for obtaining the returns of injuries inflicted in battle, which had afterwards served for forming the general tables showing the total surgical results of certain wars; and also to try and excite an interest in the subject of the adoption of a common system for collecting such information in all regular armies. There appeared to me to be some practical objections to the forms of returns which had been issued for collecting the statistics of injuries in the field during the United States' Civil War, and I thought it might be useful to mention them. These objections excited the displeasure of Dr. Otis, the able compiler of the surgical history of the war. This feeling he expressed in some remarks in the Introduction (p. 26) to the First Part of the History, and in other ways that I prefer not to refer to now. I have already replied to his remarks above mentioned, in a short paper published in the *American Journal of the Medical Sciences* for October, 1873. Although Dr. Otis has done me wrong, I am none the less ready to express my admiration of the great talents and industry which he has displayed in bringing together, in the surgical history of the War of the Rebellion, the vast amount of

information furnished by the many very expert surgeons engaged in the hospital practice of the U.S. armies, as well as in his able comments upon the results of their labours.

SECTION XI.

STATISTICS OF GUNSHOT INJURIES.

Hits to shots fired, note 1, page 577.

'History of the Siege of Gibraltar, 1779–83,' by J. Drinkwater, Captain 72nd Regt., Lond., J. Murray, 1844. See appendix, 'General Return of Casualties,' and 'Return of Expenditure of Ammunition.'

Note 2, page 577.—'Les Forteresses Françaises pendant la Guerre de 1870–71,' par J. Provost, Lt.-Col. de Génie à Vincennes, J. Dumaine, Paris.

Wounds to special missiles, note 3, page 580.

'Surgical History of Crimean War,' vol. ii., p. 264.

Note 4, page 580.—Chenu, 'Armée d'Orient,' Paris, 1865.

Note 5, page 581.—The numbers given by Fischer are: officers and men killed by rifle shot 6,969, by shell splinters, 695, or, in round numbers, 10 to 1 killed by rifle shot; wounded by rifle shot 49,093, by shell, 4389.—'Statistik der verluste in dem Kriege 1870–71, im Preussischen Heere, &c.,' von G. Fischer, Berlin, 1876, p. 6.

Casualties in battles, note 6, page 583.

M. Boudin mentions that the official report respecting the assault of Constantine in Algeria, on October 13, 1837, gave a total of 506 wounded, of whom 38 were officers, among a force of 12,453 combatants; but on the following day, the 14th, the number of wounded on the hospital returns was only 309, of whom 27 were officers. The difference was probably due to the injuries of some being slight and not requiring hospital treatment, so that they had rejoined the ranks for duty.—'Système des Ambulances des Armées Françaises et Anglaises,' p. 7, Paris, 1855.

Note 7, page 584.—So persistent is the impression that this former proceeding is still practised, that, even with regard to so comparatively recent an action as the battle of the Alma, the following statement was made in a work published by a gentleman holding an official position in a military office, and having special facilities for acquiring information on such subjects:—'The French casualties were reported as about 1,400 *hors de combat*: these are believed to include all those who died in the Dobrudscha' ('Medals of the British Army, &c.,' dedicated by permission to the Hon. Sir J. Y. Scarlett, K.C.B., Adjutant-General, &c., by T. Carter, Lond., 1861, p. 20); that is, men who had died from disease two months before the battle, and when the French army had not even landed in the Crimea. Statistics, however, are too carefully scrutinised now-a-days for such a falsification as this to be practised without speedy detection. We have sufficient proof that the total French loss at the Alma closely approached the number at first stated. Dr. Chenu's returns, founded on the names of the officers and soldiers concerned, show that the French casualties at the Alma were 141 killed, 1,197 wounded, and 3 unaccounted for; total, 1,341. The losses of the French in the Dobrudscha are separately given by Dr. Chenu, and he shows that they were far greater than is supposed in the quotation above given, or than they were generally believed to be at the time they occurred. The number of officers and men attacked by cholera in that fatal expedition was 3,138, and of them

2,277 died. Altogether in July 1854, in which month the Dobrudscha expedition started on its fatal errand, there were 8,239 cases of cholera in the French army in the East, and 5,030 men, or one-eleventh of its total strength at the time, succumbed to the scourge in that month. The plain unvarnished narrative by Dr. Chenu of the sudden visitation and effects of the cholera, by which the advance of the troops under Generals Espinasse and Jusuf was arrested in the Dobrudscha, is one of the most moving episodes in his great work on the medical and surgical history of the French army of the East.

Note 8, page 585.—'Military Gymnastics of the French,' by A. Steinmetz, Esq., Lieut. Queen's Own Light Infantry Militia, &c.—*Journal of the United Service Institution*, vol. v., p. 385.

Note 9, page 585.—'Memorandum on the Prussian Army in relation to the campaign of 1866,' by Colonel Reilly, R.H.A.

Note 10, page 587.—The following historians were consulted in respect to the strength of the French, Prussian, Russian, Austrian, and British Armies, and their casualties, in the earlier battles named in the table:—Schloezer, Meyer, Rotteck, Becker, Luder, Soltyk, Roeder, Pelet, Gourgaud, Ségur, Buturlin, Larrey, Alison, Creasy, Coxe, and others. The calculations respecting the more recent battles are based on information obtained from official sources.

Note 11, page 588, Austerlitz.—A large number of Russian and Austrian troops, who were forced into the lakes in rear of the position of the allies during the battle and drowned, are included in the 26,200 casualties. M. Thiers estimates the French loss in killed and wounded at 4,500 only.

Note 12, page 588, Maida.—Major General Sir J. Stuart's returns.

Note 13, page 588, Talavera.—'The despatches of F.M. the Duke of Wellington during his various campaigns,' vol. iii. p. 375. 'Napier's Peninsular War,' London, 1839, vol. ii., p. 406.

Note 14, page 588, Albuera.—Official returns, quoted in 'Medals of the British Army,' by T. Carter, formerly of the Adjutant General's Office, Horse-Guards, Lond. 1861, 2nd edition, p. 91. In the first returns 580 were shown as 'missing,' but as 'nearly all reported as missing subsequently rejoined their regiments,' they are omitted, in the calculations in the table.

Note 15, page 588, Badajos.—(Whole siege). Strength of the troops employed at the siege, from Napier. Op. cit., vol. iv., p. 585. Numbers killed and wounded from Carter, op. cit. p. 107. Napier, op. cit, vol. iv. p. 588, gives the loss as killed 875, wounded 3,787, missing 62. Probably an earlier return.

Note 16, page 588, Badajos.—(Assault). Napier, op. cit. vol. iv. p. 587.

Note 17, page 588, Salamanca. Napier, op. cit. vol. v. pp. 620-621. The numbers of strength and losses are exclusive of officers, sergeants, trumpeters, artillerymen, and staff. In Napier's 'History of the Peninsular War,' the strength shown is almost always the strength of effective sabres and bayonets.

Note 18, page 588, Bautzen.—These numbers include those of the losses on the 19th, 20th, and 21st May, 1813.

Note 19, page 589, Vittoria.—Napier, op. cit. vol. v. p. 622.

Note 20, page 589, Leipzic.—Some accounts give the strength of the allies at Leipsic as 240,000, and place the casualties, especially among the French, at a much higher figure.

Note 21, page 589, Toulouse.—Napier, op. cit. vol. vi. p. 707. Strength, all ranks: Anglo-Portuguese cavalry and infantry under arms, 37,917; Spaniards, 14,000; artillerymen 1,500; total 53,417. But Napier says (p. 671) only 24,000 men really fought the battle. For the total loss see Napier, vol. vi. p. 649, and Carter, op. cit. p. 118. Accepting the statement that only 24,000 were engaged, the percentage of killed would be 2·47, of wounded 16·85, and total loss 19·33.

Note 22, *page* 589, *Waterloo.*—The strength of the British troops taken from the 'Morning State' of the British army on the morning of the battle of Waterloo, 18th June, 1815. Actually present at the battle: officers 1,894; sergeants and troop quartermasters 2,061; trumpeters or drummers 700; rank and file 31,585; total 36,240. See 'Selections from the Wellington Despatches,' Gurwood, Lond. 1851, p. 862. Numbers of killed, wounded, and missing, among the British and Hanoverian troops, op. cit. p. 861. The greater number of the men returned 'missing' had gone to the rear with wounded officers and soldiers, and rejoined afterwards. The strength of the Hanoverians and the German legion, and the losses of the latter, are from Siborne.

Note 23, *page* 589, *Alma.*—British strength, inclusive of officers, sergeants, drummers, rank and file. More than half the number killed, and nearly half the number wounded, occurred in the four regiments of the light division, which assaulted the Russian hill-battery. See 'Kinglake,' vol. ii. p. 506. French and Russians, Chenu, 'Armée d'Orient,' Paris, 1865, pp. 42-44. The 1,008 Russians missing were probably wounded prisoners. This would alter the ratio of killed to wounded to 1 to 2·1.

Note 24, *page* 589, *Inkerman.*—English, official returns; French and Russians, Chenu, 'Armée d'Orient,' pp. 60, 63.

Note 25, *page* 589, *Whole Crimean War.*—British: The strength given comprehends the total number of officers, non-commissioned officers, and privates sent out to the Crimea during the war. For numbers of killed and wounded, see the 'Official Surgical History of the Crimean War,' vol. ii. p. 259 and p. 380. French: Officers and troops, Chenu, p. 574.

Note 26, *page* 589, *Montebello.*—The figures in this and the following Italian battles include officers, non-commissioned officers and rank and file, as is customary in continental army enumerations. They are taken from French official statements. The strength of the French army on the 4th June (Magenta) was 127,453; of the allied French and Sardinian armies on the 24th June (Solferino) was 187,956 combatants; the figures in the table show only the strength of the troops said to have been actually engaged.

Note 27, *page* 589, *Italian War of* 1859; *whole war*—French: Total effective combatants engaged in action during the war, Chenu, 'Guerre d'Italie,' tome ii. p. 851. All ranks are included in the killed, wounded, and missing, op. cit. p. 853. The missing include prisoners.

Note 28, *page* 589, *Shiloh.*—The number of the Union and Confederate losses in this and the following American battles is extracted from the 'Chronological Summary of Engagements and Battles' in the 'Medical and Surgical History of the War of the Rebellion,' part i. vol. ii., Washington, 1870. Six principal battles at various periods of the war have been selected for illustration. Shiloh, op. cit. p. 44.

Note 29, *page* 589, *Antietam.*—Op. cit. p. 58. Strength of all arms present for duty and casualties reported by General McClellan. Medical Director Letterman's returns show 8,350 wounded, but he says 'many cases of slight wounds are not recorded.' The numbers given of the strength and losses of Confederates under General Lee were estimated by General McClellan. The Quarter-Master General reported having buried 2,700 Confederates left dead on the field of battle. The estimates of General Lee's fighting strength are probably exaggerated, but the losses not over-estimated.

Note 30, *page* 589, *Murfreesboro'.*—Op. cit. p. 66.

Note 31, *page* 589, *Gettysburg.*—Op. cit. p. 80. Strength taken from the morning report of General Meade's aggregate force of July 1st, 1863. In this number large bodies of troops guarding trains, protecting lines of communication, &c., are understood to have been included. The Confederate strength is assumed, as General Lee is known to have had that number present for duty in

June 1863. The stated loss includes 13,621 men reported on the muster roll of the Provost Marshal of the army of the Potomac as prisoners. The 13,621 missing are believed to have been killed or wounded.

Note 32, *page* 589, *Chickamauga.*—Op. cit. p. 87. General Rosencrans states he had 'less than 50,000 men in line of battle.' The Adjutant-General of the army reported General Rosencrans' aggregate at this battle as 5,570 officers, and 88,706 men; total 94,276. But this is believed to include all the troops in the immense 'department of the Cumberland.' A very large number of the wounded of General Rosencrans' army were left on the field; these doubtless form part of the 4,945 reported as 'missing.' The Confederate strength is the number of General Bragg's army after being reinforced by General Longstreet's corps. The Confederate 'missing' were prisoners.

Note 33, *page* 589, *Wilderness.*—Op. cit. p. 106. Union strength approximate.

Note 34, *page* 590. *United States' whole war.*—'Medical and Surgical History of the War of the Rebellion,' part i. vol. ii. Introduction, page 26. The aggregate missing of the Confederates includes the armies surrendered.

Note 35, *page* 590, *New Zealand War.*—Strength given is the average strength of the troops employed throughout the war. See 'Army Medical Reports,' vol. vii. 1867, pp. 400 and 411. See also Appendix, p. 311, to 'The Maori War in New Zealand,' by Major-General Sir J. E. Alexander, Lond. 1873.

Note 36, *page* 590, *Prusso-Danish War of* 1864.—From General-Arzt. Dr. Löffler's Returns. (*a*) The number of killed on the battle-field. The strength given is the *average total strength* of the Prussian Contingent. The greatest strength was 63,500. (*b*) Proportion of strength actually engaged. See Report of General-Arzt. Löffler. (*c*) The number of wounded among the Danes mentioned in Dr. Löffler's report is probably the number admitted into the Prussian field-hospitals, the slightly wounded having made their escape. This will explain the large proportion of killed to wounded among the Danes.

Note 37, *page* 590, *Koniggratz.*—(*a*) Prussians. In the first line the full fighting strength of the Prussians, combatants of all ranks, is given. (*b*) But of the fighting strength about 80,000 infantry, and 12,000 cavalry never came into action: this number is deducted in the second line, the strength of troops engaged being given alone. (*c*) Austrians and Saxons. The Austrian official accounts give as the strength: infantry (Austrian and Saxon together) 174,902; cavalry 23,798; artillery 16,328; total 215,028: this number is taken as the strength in the first line. (*d*) But as 65,000 were reported as not having been engaged, the strength reduced by this number is taken in line (*d*).

Colonel Cooke, R.E., who has given a summary of the campaign in Austria of 1866, including a description of the battle of Königgratz, in the Professional Papers of the Corps of Royal Engineers (vol. xv., 1866, page 174) has remarked: 'The losses in this battle were very small, considering the number of men engaged and the duration of the fighting.' No doubt they were so, if the total numbers on each side are regarded as all having been engaged in the conflict, and this is probably the only way in which the subject would be regarded by combatant officers. But, regarded surgically, that is, considering the number of the wounded to be professionally attended to and cared for, the losses in this battle were very large. And practically we know that the losses were so very large that the necessary attention could not possibly be given to them, and that many—no one can say how many—lives were lost in consequence. What with the fact that the Prussians marched on their way to Vienna on the day but one after that on which the battle was fought, taking with them a large proportion of the surgical staff, the 7,000 wounded Prussians and the enormous number of wounded Austrians and Saxons, who remained in the hands of the victors lying scattered over an extensive area, together formed a multitude out of all proportion to the limited surgical staff and attendants who were available for rendering the help required of them. Days elapsed before the needed assistance could be brought

from other places; unhappily only after the numbers wanting it had been very considerably lessened by death. Colonel Cooke states the total engaged in the battle as 415,000, and the number killed and wounded as 28,000. He thus shows the proportion of killed and wounded to have been $\frac{1}{15}$th of the numbers engaged. The action lasted from about 8 A.M. to about 4 P.M.

Note 38, *page* 590, *Weissenburg.*—The strength, numerical losses in killed, wounded, and missing in this and the succeeding battles of the Franco-German War are taken from 'Die Verluste der Deutschen Armeen, von Dr. Engel.' Berlin, 1872.

Note 39, *page* 590, *Whole Franco-German War.*—The strength given by Engel of the different battles, and in summing up the total, is the *normal* strength of the armies in the field; but, as the *losses* were probably replaced from time to time, the number of the killed, wounded, and missing might well be added. If this were done, as is done in the British strength given for the Crimean War, where every individual sent to recruit the strength is included, then the percentage of the losses would be proportionally diminished, and the ratio of killed to wounded also changed. The 17,570 shown as killed were killed on the battle-field, or died within twenty-four hours after being wounded. As there were still 4,009 missing at the conclusion of the war, they may be fairly included among the dead, but whether from wounds or disease cannot be determined.

The ratio of killed to wounded, according to Fischer, who limits his statistics to the armies of Prussia and the North German contingents, is nearly the same as is shown in the table for all the Germans. His figures are, killed 13,556; wounded, 75,321; total killed and wounded 88,877. These give 15·2 per cent. killed and 84·8 per cent. wounded; or about 1 killed to 5·6 wounded.

Target area of the human body, note 40, *page* 592.

'Tables of the Skeleton and Muscles of the Human Body. By B. S. Albinus.' Translated from the Latin, &c., London, 1749, Elephant folio. Tab. i. External muscles of the body, Full front. Tab. ix., The same, Side view.

Note 41, *page* 592.—Andrew Bell's Edit. of Albinus, dated Edin.: Feb. 17, 1777.

Note 42, *page* 594.—Taken from plate 19, in 'The Proportions of the Human Body measured from the most beautiful antique statues.' By Mons. Audran &c., in 27 large folio plates. Lond: C. Bowles, 1770.

Note 43, *page* 596.—The number of gunshot wounds of the hand and fingers examined on this occasion was nearly three thousand (2,632). Some unscrupulous persons wishing to lessen in the eyes of Napoleon the number of wounds caused in the battles of Lützen, Bautzen, and Würtzen, had ascribed many of them to self-mutilation. After examining each wounded man individually, the board of which Larrey was president declared that the charge made against these wounded soldiers was false. Although the Emperor was at first irritated with Larrey at the decision, after reading the papers he was so convinced of its justice, and of the courage with which Larrey had repelled the accusation against the troops concerned, that he sent him his portrait enriched with diamonds. See 'Campagnes du Baron D. J. Larrey (Campagne de Russie)' Tome iv. Paris 1817, p. 170, and for a fuller account of the transaction, 'Le Baron Larrey,' par le Général Baron Ambert, Paris 1863, p. 50.

Note 44, *page* 603.—'Das Preussische Militair-Sanitätswesen and seine Reform,' Löffler, Berlin, 1868, part ii. p. 24.

Note 45, *page* 605.—'Army Medical Reports,' vol. vii. p. 473.

Note 46, *page* 605.—'General Bericht über den Gesundheitsdienst im Feldzuge gegen Dänemark 1864.' Löffler, Berlin, 1867, p. 46.

Note 47, *page* 607.—Chenu, 'Campagne d'Italie,' tome ii. p. 849. (Wounds and amputations the situations of which are undetermined are omitted.)

Note 48, *page* 607.—Wounds of the abdomen by bullets, large projectiles, and fragments of shell: wounds of the inguinal region are counted with those of the abdomen. Herniæ and injuries resulting from different causes than projectiles are excluded.

Note 49, *page* 607.—The numbers under wounds of upper and lower extremities include the cases in which amputations or other surgical operations were performed. Wounds of the scapula and clavicle are included under upper extremities in Dr. Chenu's classification; in some others they are classified with wounds of the chest.

Note 50, *page* 608.—See 'Surgical History of Crimean War,' vol. ii. p. 259, and p. 380. A slight discrepancy is shown in the percentages of mortality of wounds of the extremities between the table in the text and that in the surgical history of the war. This is owing to wounds of joints being shown separately in the table in the text.

Note 51, *page* 608.—Calculated from the classified returns in 'Army Medical Reports,' vol. vii. p. 474, to p. 477.

Note 52, *page* 609.—Note on an interleaved copy of Sir C. Bell's 'Dissertation on Gunshot Wounds' in the Bell collection at Netley. (See 'Army Medical Reports,' vol. vii. p. 596. London, 1867.)

Note 53, *page* 609.—Löffler, op. cit. p. 46. Dr. Löffler's history of the Prusso-Danish war is not completed so far as regards the detailed history of wounds of the lower extremities. The numbers under joints, blood-vessels, and nerves, refer only to those of the upper extremity (Löffler, p. 137); the corresponding anatomical structures of the lower extremities are included in the numbers wounded under 'lower extremities.'

Note 54, *page* 610.—Wounds of the scapula and clavicle are included by Stromeyer under the heading of upper extremities in this table. This will probably increase the ratio of mortality.

Note 55, *page* 611.—Corrected mean, obtained by multiplying each ratio by its combination weight, i.e. the square root of the total number of cases, then summing up the ratios thus treated and dividing by the sum of the square roots of the total numbers of cases in each group.

Note 56, *page* 612.—The figures in this table are taken from the General Return C., 'Crimean History,' vol. ii. History of Disease, sect. xiii. p. 246.

Note 57, *page* 612.—Op. supra cit. vol. ii. p. 388.

Note 58, *page* 615.—The numbers in the table regarding the Italian campaign are from the general table at p. 849, tome ii., of Chenu's 'Armée d'Italie;' those of the Crimean War from the separate tables in Chenu's 'Armée d'Orient.' No general table is given in Chenu's Crimean History, similar to that in the history of the Italian War, nor are the numbers in the columns of 'Pensionnés' in the former divided into 'Retraités' and 'Pensionnés temporairement,' as they are at p. 849 above quoted of the second volume of the latter work.

Note 59, *page* 617.—'Army Medical Reports for 1865,' vol. vii. p. 479.

Note 60, *page* 617.—'Surgical History of Crimean War,' vol. ii. p. 380.

Note 61, *page* 619.—These two tables have been formed from information contained in different parts of the 'Official Surgical History of the Crimean War' (see pp. 257–259, pp. 388 et seq.)

Note 62, *page* 620.—See 'Army Medical Reports,' vol. xv, p. 258.

INDEX.

Spottiswoode & Co., Printers, New-street Square, London.

MARCH 1877

CLASSIFIED LISTS OF BOOKS

(NEW WORKS AND NEW EDITIONS)

IN

MISCELLANEOUS

AND

GENERAL LITERATURE

FOLLOWED BY

AN ALPHABETICAL INDEX UNDER AUTHORS' NAMES

London
Longmans, Green & Co.
Paternoster Row
1877.

The History of England from the Fall of Wolsey to the Defeat of the Spanish Armada. By J. A. FROUDE, M.A.

CABINET EDITION, 12 vols. cr. 8vo. £3. 12*s*.
LIBRARY EDITION, 12 vols. 8vo. £8. 18*s*.

The English in Ireland in the Eighteenth Century. By J. A. FROUDE, M.A. 3 vols. 8vo. £2. 8*s*.

Journal of the Reigns of King George IV. and King William IV. By the late C. C. F. GREVILLE, Esq. Edited by H. REEVE, Esq. Fifth Edition. 3 vols. 8vo. price 36*s*.

The Life of Napoleon III. derived from State Records, Unpublished Family Correspondence, and Personal Testimony. By BLANCHARD JERROLD. In Four Volumes, 8vo. with numerous Portraits and Facsimiles. VOLS. I. and II. price 18*s*. each.

*** The Third Volume is in the press.

Introductory Lectures on Modern History delivered in Lent Term 1842; with the Inaugural Lecture delivered in December 1841. By the late Rev. T. ARNOLD, D.D. 8vo. price 7*s*. 6*d*.

On Parliamentary Government in England; its Origin, Development, and Practical Operation. By ALPHEUS TODD. 2 vols. 8vo. price £1. 17*s*.

The Constitutional History of England since the Accession of George III. 1760 1870. By Sir THOMAS ERSKINE MAY, K.C.B. D.C.L. Fifth Edition. 3 vols. crown 8vo. 18*s*.

Democracy in Europe; a History. By Sir THOMAS ERSKINE MAY, K.C.B. D.C.L. 2 vols. 8vo. [*In the press.*

History of Civilisation in England and France, Spain and Scotland. By HENRY THOMAS BUCKLE. 3 vols. crown 8vo. 24*s*.

Lectures on the History of England from the Earliest Times to the Death of King Edward II. By W. LONGMAN, F.S.A. Maps and Illustrations. 8vo. 15*s*.

History of the Life & Times of Edward III. By W. LONGMAN, F.S.A. With 9 Maps, 8 Plates, and 16 Woodcuts. 2 vols. 8vo. 28*s*.

The Life of Simon de Montfort, Earl of Leicester, with special reference to the Parliamentary History of his time. By GEORGE WALTER PROTHERO, Fellow and Lecturer in History, King's College, Cambridge. Crown 8vo. 9*s*.

History of England under the Duke of Buckingham and Charles the First, 1624 1628. By S. R. GARDINER, late Student of Ch. Ch. 2 vols. 8vo. with 2 Maps, 24*s*.

The Personal Government of Charles I. from the Death of Buckingham to the Declaration of the Judges in favour of Ship Money, 1628–1637. By S. R. GARDINER, late Student of Ch. Ch. 2 vols. 8vo. [*In the press.*

Popular History of France, from the Earliest Times to the Death of Louis XIV. By ELIZABETH M. SEWELL. With 8 Maps. Crown 8vo. 7*s*. 6*d*.

History of Prussia, from the Earliest Times to the Present Day; tracing the Origin and Development of her Military Organisation. By Capt. W. J. WYATT. VOLS. I. & II. A.D. 700 to A.D. 1525. 8vo. 36*s*.

A Student's Manual of the History of India from the Earliest Period to the Present. By Col. MEADOWS TAYLOR, M.R.A.S. Second Thousand. Crown 8vo. Maps, 7*s*. 6*d*.

Indian Polity; a View of the System of Administration in India. By Lieut.-Col. G. CHESNEY. 2nd Edition, revised, with Map. 8vo. 21*s*.

Essays in Modern Military Biography. By Col. C. C. CHESNEY, R.E. 8vo. 12*s*. 6*d*.

Waterloo Lectures; a Study of the Campaign of 1815. By Col. C. C. CHESNEY, R.E. Third Edition. 8vo. Map, 10*s.* 6*d.*

The Oxford Reformers— John Colet, Erasmus, and Thomas More; being a History of their Fellow-Work. By F. SEEBOHM. Second Edition. 8vo. 14*s.*

The Mythology of the Aryan Nations. By the Rev. G. W. COX, M.A. late Scholar of Trinity College, Oxford. 2 vols. 8vo. 28*s.*

A History of Greece. By the Rev. G. W. COX, M.A. VOLS. I. & II. 8vo. Maps, 30*s.*

General Hist. of Greece to the Death of Alexander the Great; with a Sketch of the Subsequent History to the Present Time. By the Rev. G. W. COX, M.A. Crown 8vo. with Maps, 7*s.* 6*d.*

General History of Rome from the Foundation of the City to the Fall of Augustulus, B.C. 753–A.D. 476. By Dean MERIVALE, D.D. Crown 8vo. Maps, 7*s.* 6*d.*

History of the Romans under the Empire. By Dean MERIVALE, D.D. 8 vols. post 8vo. 48*s.*

The Fall of the Roman Republic; a Short History of the Last Century of the Commonwealth. By Dean MERIVALE, D.D. 12mo. 7*s.* 6*d.*

The History of Rome. By WILHELM IHNE. VOLS. I. & II. 8vo. 30*s.* VOL. III. is in the press.

The Sixth Oriental Monarchy; or, the Geography, History, and Antiquities of Parthia. By G. RAWLINSON, M.A. With Maps and Illustrations. 8vo. 16*s.*

The Seventh Great Oriental Monarchy; or, a History of the Sassanians. By G. RAWLINSON, M.A. With Map and 95 Illustrations. 8vo. 28*s.*

Encyclopædia of Chronology, Historical and Biographical; comprising the Dates of all the Great Events of History, including Treaties, Alliances, Wars, Battles, &c. By B. B. WOODWARD, B.A. and W. L. R. CATES. 8vo. 42*s.*

The History of European Morals from Augustus to Charlemagne. By W. E. H. LECKY, M.A. 2 vols. crown 8vo. 16*s.*

History of the Rise and Influence of the Spirit of Rationalism in Europe. By W. E. H. LECKY, M.A. 2 vols. crown 8vo. 16*s.*

The Native Races of the Pacific States of North America. By H. H. BANCROFT. 5 vols. 8vo. £6. 5*s.*

History of the Mongols from the Ninth to the Nineteenth Century. By HENRY H. HOWORTH, F.S.A. VOL. I. *the Mongols Proper and the Kalmuks*; with Two Coloured Maps. Royal 8vo. 28*s.*

Islam under the Arabs. By ROBERT DURIE OSBORN, Major in the Bengal Staff Corps. 8vo. 12*s.*

Introduction to the Science of Religion, Four Lectures delivered at the Royal Institution; with Two Essays on False Analogies and the Philosophy of Mythology. By MAX MÜLLER, M.A. Crown 8vo. 10*s.* 6*d.*

Zeller's Stoics, Epicureans, and Sceptics. Translated by the Rev. O. J. REICHEL, M.A. Cr. 8vo. 14*s.*

Zeller's Socrates & the Socratic Schools. Translated by the Rev. O. J. REICHEL, M.A. Crown 8vo. New Edition in the press.

Zeller's Plato & the Older Academy. Translated by S. FRANCES ALLEYNE and ALFRED GOODWIN, B.A. Crown 8vo. 18*s.*

Sketch of the History of the Church of England to the Revolution of 1688. By T. V. SHORT, D.D. sometime Bishop of St. Asaph. Crown 8vo. 7*s.* 6*d.*

The History of Philosophy, from Thales to Comte. By GEORGE HENRY LEWES. Fourth Edition. 2 vols. 8vo. 32*s.*

The Childhood of the English Nation; or, the Beginnings of English History. By ELLA S. ARMITAGE. Fcp. 8vo. 2*s.* 6*d.*

Epochs of Modern History. Edited by E. E. MORRIS, M.A. J. S. PHILLPOTTS, B.C.L. and C. COLBECK, M.A. Eleven volumes now published, each complete in itself, in fcp. 8vo. with Maps & Index:—

Cox's Crusades, 2*s.* 6*d.*

Creighton's Age of Elizabeth, 2*s.* 6*d.*

Gairdner's Houses of Lancaster and York, 2*s.* 6*d.*

Gardiner's Puritan Revolution, 2*s.* 6*d.*

Gardiner's Thirty Years' War, 2*s.* 6*d.*

Hale's Fall of the Stuarts, 2*s.* 6*d.*

Ludlow's War of American Independence, 2*s.* 6*d.*

Morris's Age of Anne, 2*s.* 6*d.*

Seebohm's Protestant Revolution, price 2*s.* 6*d.*

Stubbs's Early Plantagenets, 2*s.* 6*d.*

Warburton's Edward III. 2*s.* 6*d.*

⁎ Other Epochs in preparation, in continuation of the Series.

The Student's Manual of Modern History; containing the Rise and Progress of the Principal European Nations. By W. COOKE TAYLOR, LL.D. Crown 8vo. 7*s.* 6*d.*

The Student's Manual of Ancient History; containing the Political History, Geographical Position, and Social State of the Principal Nations of Antiquity. By W. COOKE TAYLOR, LL.D. Crown 8vo. 7*s.* 6*d.*

Epochs of Ancient History. Edited by the Rev. G. W. COX, M.A. and by C. SANKEY, M.A. Ten volumes, each complete in itself, in fcp. 8vo. with Maps & Index:—

Beesly's Gracchi, Marius & Sulla, 2*s.* 6*d.*

Capes's Age of the Antonines, 2*s.* 6*d.*

Capes's Early Roman Empire, 2*s.* 6*d.*

Cox's Athenian Empire, 2*s.* 6*d.*

Cox's Greeks & Persians, 2*s.* 6*d.*

Curteis's Macedonian Empire, 2*s.* 6*d.*

Ihne's Rome to its Capture by the Gauls, 2*s.* 6*d.*

Merivale's Roman Triumvirates, 2*s.* 6*d.*

Sankey's Spartan & Theban Supremacy. [*In the press.*

Smith's Rome & Carthage, the Punic Wars. [*In the press.*

BIOGRAPHICAL WORKS.

The Life and Letters of Lord Macaulay. By his Nephew, G. OTTO TREVELYAN, M.P. Second Edition, with Additions and Corrections. 2 vols. 8vo. Portrait, 36s.

The Life of Sir William Fairbairn, Bart. F.R.S. Partly written by himself; edited and completed by W. POLE, F.R.S. 8vo. Portrait, 18*s.*

Arthur Schopenhauer, his Life and his Philosophy. By HELEN ZIMMERN. Post 8vo. Portrait, 7*s.* 6*d.*

The Life, Works, and Opinions of Heinrich Heine. By WILLIAM STIGAND. 2 vols. 8vo. Portrait, 28*s.*

The Life and Letters of Mozart. Translated from the German Biography of Dr. LUDWIG NOHL by Lady WALLACE. 2 vols. post 8vo. with Two Portraits. [*Nearly ready.*

Felix Mendelssohn's Letters from Italy and Switzerland, and Letters from 1833 to 1847. Translated by Lady WALLACE. With Portrait. 2 vols. crown 8vo. 5*s.* each.

A System of Logic, Ratiocinative and Inductive. By JOHN STUART MILL. 2 vols. 8vo. 25*s.*

Examination of Sir William Hamilton's Philosophy, and of the principal Philosophical Questions discussed in his Writings. By JOHN STUART MILL. 8vo. 16*s.*

Dissertations and Discussions. By JOHN STUART MILL. 4 vols. 8vo. price £2. 6*s.* 6*d.*

Analysis of the Phenomena of the Human Mind. By JAMES MILL. With Notes, Illustrative and Critical. 2 vols. 8vo. 28*s.*

The Law of Nations considered as Independent Political Communities; the Rights and Duties of Nations in Time of War. By Sir TRAVERS TWISS, D.C.L. 8vo. 21*s.*

Church and State; their Relations Historically Developed. By H. GEFFCKEN, Prof. of International Law in the Univ. of Strasburg. Translated, with the Author's assistance, by E. F. TAYLOR. 2 vols. 8vo. 42*s.*

A Systematic View of the Science of Jurisprudence. By SHELDON AMOS, M.A. 8vo. 18*s.*

A Primer of the English Constitution and Government. By S. AMOS, M.A. Crown 8vo. 6*s.*

Outlines of Civil Procedure; a General View of the Supreme Court of Judicature and of the whole Practice in the Common Law and Chancery Divisions. By E. S. ROSCOE, Barrister-at-Law. 12mo. 3*s.* 6*d.*

A Sketch of the History of Taxes in England from the Earliest Times to the Present Day. By STEPHEN DOWELL. VOL. I. to the Civil War 1642. 8vo. 10*s.* 6*d.*

Principles of Economical Philosophy. By H. D. MACLEOD, M.A. Barrister-at-Law. Second Edition in Two Volumes. VOL. I. 8vo. 15*s.* VOL. II. PART I. price 12*s.*

The Institutes of Justinian; with English Introduction, Translation, and Notes. By T. C. SANDARS, M.A. 8vo. 18*s.*

Lord Bacon's Works, collected & edited by R. L. ELLIS, M.A. J. SPEDDING, M.A. and D. D. HEATH. 7 vols. 8vo. £3. 13*s.* 6*d.*

Letters and Life of Francis Bacon, including all his Occasional Works. Collected and edited, with a Commentary, by J. SPEDDING. 7 vols. 8vo. £4. 4*s.*

The Nicomachean Ethics of Aristotle, newly translated into English by R. WILLIAMS, B.A. Second Edition, thoroughly revised. Crown 8vo. 7*s.* 6*d.*

Aristotle's Politics, Books I. III. IV. (VII.) the Greek Text of Bekker, with an English Translation by W. E. BOLLAND, M.A. and Short Introductory Essays by A. LANG, M.A. Crown 8vo. 7*s.* 6*d.*

The Politics of Aristotle; Greek Text, with English Notes. By RICHARD CONGREVE, M.A. 8vo. 18*s.*

The Ethics of Aristotle; with Essays and Notes. By Sir A. GRANT, Bart. M.A. LL.D. 2 vols. 8vo. 32*s.*

Bacon's Essays, with Annotations. By R. WHATELY, D.D. 8vo. 10*s.* 6*d.*

Picture Logic; an Attempt to Popularise the Science of Reasoning. By A. SWINBOURNE, B.A. Fcp. 8vo. price 5*s.*

Elements of Logic. By R. WHATELY, D.D. 8vo. 10*s.* 6*d.* Crown 8vo. 4*s.* 6*d.*

Elements of Rhetoric. By R. WHATELY, D.D. 8vo. 10*s.* 6*d.* Crown 8vo. 4*s.* 6*d.*

Lectures on the Science of Language. By F. MAX MÜLLER, M.A. &c. 2 vols. crown 8vo. 16*s.*

Chips from a German Workshop; Essays on the Science of Religion, and on Mythology, Traditions & Customs. By F. MAX MÜLLER, M.A. 4 vols. 8vo. £2. 18*s.*

Chapters on Language. By F. W. FARRAR, D.D. Crown 8vo. price 5*s.*

Families of Speech. Four Lectures delivered at the Royal Institution. By F. W. FARRAR, D.D. Crown 8vo. 3*s.* 6*d.*

Apparitions; a Narrative of Facts. By the Rev. B. W. SAVILE, M.A. Crown 8vo. 4*s.* 6*d.*

Miscellaneous Writings of John Conington, M.A. Edited by J. A. SYMONDS, M.A. With a Memoir by H. J. S. SMITH, M.A. 2 vols. 8vo. 28*s.*

The Essays and Contributions of A. K. H. B. Uniform Cabinet Editions in crown 8vo.

Recreations of a Country Parson, Two Series, 3*s.* 6*d.* each.

Landscapes, Churches, and Moralities, price 3*s.* 6*d.*

Seaside Musings, 3*s.* 6*d.*

Changed Aspects of Unchanged Truths, 3*s.* 6*d.*

Counsel and Comfort from a City Pulpit, 3*s.* 6*d.*

Lessons of Middle Age, 3*s.* 6*a.*

Leisure Hours in Town, 3*s.* 6*d.*

Autumn Holidays of a Country Parson, price 3*s.* 6*d.*

Sunday Afternoons at the Parish Church of a University City, 3*s.* 6*d.*

The Commonplace Philosopher in Town and Country, 3*s.* 6*d.*

Present-Day Thoughts, 3*s.* 6*d.*

Critical Essays of a Country Parson, price 3*s.* 6*d.*

The Graver Thoughts of a Country Parson, Three Series, 3*s.* 6*d.* each.

DICTIONARIES and OTHER BOOKS of REFERENCE.

Dictionary of the English Language. By R. G. LATHAM, M.A. M.D. Abridged from Dr. Latham's Edition of Johnson's English Dictionary. Medium 8vo. 24*s.*

A Dictionary of the English Language. By R. G. LATHAM, M.A. M.D. Founded on the Dictionary of Dr. S. Johnson, as edited by the Rev. H. J. TODD, with numerous Emendations and Additions. 4 vols. 4to. £7.

Thesaurus of English Words and Phrases, classified and arranged so as to facilitate the expression of Ideas, and assist in Literary Composition. By P. M. ROGET, M.D. Crown 8vo. 10*s.* 6*d.*

English Synonymes. By E. J. WHATELY. Edited by R. WHATELY, D.D. Fcp. 8vo. 3*s.*

Handbook of the English Language. For the Use of Students of the Universities and the Higher Classes in Schools. By R. G. LATHAM, M.A. M.D. Crown 8vo. 6*s.*

A Practical Dictionary of the French and English Languages. By LÉON CONTANSEAU, many years French Examiner for Military and Civil Appointments, &c. Post 8vo. price 7*s.* 6*d.*

Contanseau's Pocket Dictionary, French and English, abridged from the Practical Dictionary by the Author. Square 18mo. 3*s.* 6*d.*

A New Pocket Dictionary of the German and English Languages. By F. W. LONGMAN, Balliol College, Oxford. Square 18mo. price 5*s.*

A Practical Dictionary of the German Language; German-English and English-German. By Rev. W. L. BLACKLEY, M.A. and Dr. C. M. FRIEDLÄNDER. Post 8vo. 7*s.* 6*d.*

A Dictionary of Roman and Greek Antiquities. With 2,000 Woodcuts illustrative of the Arts and Life of the Greeks and Romans. By A. RICH, B.A. Crown 8vo. 7*s.* 6*d.*

A Greek-English Lexicon. By H. G. LIDDELL, D.D. Dean of Christchurch, and R. SCOTT, D.D. Dean of Rochester. Crown 4to. 36*s.*

A Lexicon, Greek and English, abridged for Schools from Liddell and Scott's Greek-English Lexicon. Square 12mo. 7*s.* 6*d.*

An English-Greek Lexicon, containing all the Greek Words used by Writers of good authority. By C. D. YONGE, M.A. 4to. 21*s.*

Mr. Yonge's Lexicon, English and Greek, abridged from his larger Lexicon. Square 12mo. 8*s.* 6*d.*

A Latin-English Dictionary. By JOHN T. WHITE, D.D. Oxon. and J. E. RIDDLE, M.A. Oxon. Sixth Edition, revised. 1 vol. 4to. 28*s.*

White's College Latin-English Dictionary; abridged from the Parent Work for the use of University Students. Medium 8vo. 15*s.*

A Latin-English Dictionary adapted for the use of Middle-Class Schools. By JOHN T. WHITE, D.D. Oxon. Square fcp. 8vo. 3*s.*

White's Junior Student's Complete Latin-English and English-Latin Dictionary. Square 12mo. price 12*s.*

Separately { ENGLISH-LATIN, 5*s.* 6*d.*
LATIN-ENGLISH, 7*s.* 6*d.*

M'Culloch's Dictionary, Practical, Theoretical, and Historical, of Commerce and Commercial Navigation. Edited and corrected to 1876 by H. G. REID. 8vo. 63*s.* Second SUPPLEMENT, price 3*s.* 6*d.*

A General Dictionary of Geography, Descriptive, Physical, Statistical, and Historical; forming a complete Gazetteer of the World. By A. KEITH JOHNSTON. New Edition (1877), thoroughly revised. Medium 8vo. 42*s.*

Maunder's Treasury of Knowledge and Library of Reference; comprising an English DICTIONARY and Grammar, Universal Gazetteer, Classical Dictionary, Chronology, Law Dictionary, Synopsis of the Peerage, Useful Tables, &c. Fcp. 8vo. 6*s.*

The Treasury of Bible Knowledge; being a DICTIONARY of the Books, Persons, Places, Events, and other Matters of which mention is made in Holy Scripture. By the Rev. J. AYRE, M.A. With Maps, Plates, and many Woodcuts. Fcp. 8vo. 6*s.*

The Public Schools Atlas of Modern Geography, in 31 entirely new Coloured Maps. Edited with an Introduction by Rev. G. BUTLER, M.A. In imperial 8vo. or imperial 4to. price 5*s.* cloth.

The Public Schools Atlas of Ancient Geography, in 28 entirely new Coloured Maps. Edited with an Introduction by the Rev. G. BUTLER, M.A. In imperial 8vo. or imperial 4to. price 7*s.* 6*d.* cloth.

ASTRONOMY and METEOROLOGY.

The Universe and the Coming Transits; Researches into and New Views respecting the Constitution of the Heavens. By R. A. PROCTOR, B.A. With 22 Charts and 22 Diagrams. 8vo. 16*s*.

Saturn and its System. By R. A. PROCTOR, B.A. 8vo. with 14 Plates, 14*s*.

The Transits of Venus; A Popular Account of Past and Coming Transits. By R. A. PROCTOR, B.A. 20 Plates (12 Coloured) and 27 Woodcuts. Crown 8vo. 8*s*. 6*d*.

Essays on Astronomy. A Series of Papers on Planets and Meteors, the Sun and Sun-surrounding Space, Star and Star Cloudlets. By R. A. PROCTOR, B.A. With 10 Plates and 24 Woodcuts. 8vo. 12*s*.

The Moon; her Motions, Aspects, Scenery, and Physical Condition. By R. A. PROCTOR, B.A. With Plates, Charts, Woodcuts, and Lunar Photographs. Crown 8vo. 15*s*.

The Sun; Ruler, Light, Fire, and Life of the Planetary System. By R. A. PROCTOR, B.A. With Plates & Woodcuts. Crown 8vo. 14*s*.

The Orbs Around Us; a Series of Essays on the Moon & Planets, Meteors & Comets, the Sun & Coloured Pairs of Suns. By R. A. PROCTOR, B.A. With Chart and Diagrams. Crown 8vo. 7*s*. 6*d*.

Other Worlds than Ours; The Plurality of Worlds Studied under the Light of Recent Scientific Researches. By R. A. PROCTOR, B.A. With 14 Illustrations. Cr. 8vo. 10*s*. 6*d*.

Brinkley's Astronomy. Revised and partly re-written by JOHN W. STUBBS, D.D. and F. BRUNNOW, Ph.D. With 49 Diagrams. Crown 8vo. price 6*s*.

Outlines of Astronomy. By Sir J. F. W. HERSCHEL, Bart. M.A. Latest Edition, with Plates and Diagrams. Square crown 8vo. 12*s*.

The Moon, and the Condition and Configurations of its Surface. By E. NEISON, F.R. Ast. Soc. &c. With 26 Maps and 5 Plates. Medium 8vo. 31*s*. 6*d*.

Celestial Objects for Common Telescopes. By T. W. WEBB, M.A. With Map of the Moon and Woodcuts. Crown 8vo. 7*s*. 6*d*.

A New Star Atlas, for the Library, the School, and the Observatory, in 12 Circular Maps (with 2 Index Plates). By R. A. PROCTOR, B. A. Crown 8vo. 5*s*.

Larger Star Atlas, for the Library, in Twelve Circular Maps, photolithographed by A. Brothers, F.R.A.S. With 2 Index Plates and a Letterpress Introduction. By R. A. PROCTOR, B.A. Small folio, 25*s*.

Dove's Law of Storms, considered in connexion with the Ordinary Movements of the Atmosphere. Translated by R. H. SCOTT, M.A. 8vo. 10*s*. 6*d*.

Air and Rain; the Beginnings of a Chemical Climatology. By R. A. SMITH, F.R.S. 8vo. 24*s*.

Air and its Relations to Life, 1774–1874; a Course of Lectures delivered at the Royal Institution of Great Britain. By W. N. HARTLEY, F.C.S. With 66 Woodcuts. Small 8vo. 6*s*.

Schellen's Spectrum Analysis, in its Application to Terrestrial Substances and the Physical Constitution of the Heavenly Bodies. Translated by JANE and C. LASSELL, with Notes by W. HUGGINS, LL.D. F.R.S. 8vo. Plates and Woodcuts, 28*s*.

NATURAL HISTORY and PHYSICAL SCIENCE.

Professor Helmholtz' Popular Lectures on Scientific Subjects. Translated by E. ATKINSON, F.C.S. With numerous Wood Engravings. 8vo. 12*s.* 6*d.*

On the Sensations of Tone, as a Physiological Basis for the Theory of Music. By H. HELMHOLTZ, Professor of Physiology in the University of Berlin. Translated by A. J. ELLIS, F.R.S. 8vo. 36*s.*

Ganot's Natural Philosophy for General Readers and Young Persons; a Course of Physics divested of Mathematical Formulæ and expressed in the language of daily life. Translated by E. ATKINSON, F.C.S. Second Edition, with 2 Plates and 429 Woodcuts. Crown 8vo. 7*s.* 6*d.*

Ganot's Elementary Treatise on Physics, Experimental and Applied, for the use of Colleges and Schools. Translated and edited by E. ATKINSON, F.C.S. Seventh Edition, with 4 Coloured Plates and 758 Woodcuts. Post 8vo. 15*s.*

Arnott's Elements of Physics or Natural Philosophy. Seventh Edition, edited by A. BAIN, LL.D. and A. S TAYLOR, M.D. F.R.S. Crown 8vo. Woodcuts, 12*s.* 6d.

The Correlation of Physical Forces. By the Hon. Sir W. R. GROVE, F.R.S. &c. Sixth Edition, with other Contributions to Science. 8vo. 15*s.*

Weinhold's Introduction to Experimental Physics; including Directions for Constructing Physical Apparatus and for Making Experiments. Translated by B. LOEWY, F.R.A.S. With a Preface by G. C. FOSTER, F.R.S. 8vo. Plates & Woodcuts 31*s.* 6*d.*

Principles of Animal Mechanics. By the Rev. S. HAUGHTON, F.R.S. Second Edition. 8vo. 21*s.*

Fragments of Science. By JOHN TYNDALL, F.R.S. Fifth Edition, with a New Introduction. Crown 8vo. 10*s.* 6*d.*

Heat a Mode of Motion. By JOHN TYNDALL, F.R.S. Fifth Edition, Plate and Woodcuts. Crown 8vo. 10*s.* 6*d.*

Sound. By JOHN TYNDALL, F.R.S. Third Edition, including Recent Researches on Fog-Signalling; Portrait and Woodcuts. Crown 8vo. price 10*s.* 6*d.*

Researches on Diamagnetism and Magne-Crystallic Action; including Diamagnetic Polarity. By JOHN TYNDALL, F.R.S. With 6 Plates and many Woodcuts. 8vo. 14*s.*

Contributions to Molecular Physics in the domain of Radiant Heat. By JOHN TYNDALL, F.R.S. With 2 Plates and 31 Woodcuts. 8vo. 16*s.*

Six Lectures on Light, delivered in America in 1872 and 1873. By JOHN TYNDALL, F.R.S. Second Edition, with Portrait, Plate, and 59 Diagrams. Crown 8vo. 7*s.* 6*d.*

Notes of a Course of Nine Lectures on Light, delivered at the Royal Institution. By JOHN TYNDALL, F.R.S. Crown 8vo. 1*s.* sewed, or 1*s.* 6*d.* cloth.

Notes of a Course of Seven Lectures on Electrical Phenomena and Theories, delivered at the Royal Institution. By JOHN TYNDALL, F.R.S. Crown 8vo. 1*s.* sewed, or 1*s.* 6*d.* cloth.

A Treatise on Magnetism, General and Terrestrial. By H. LLOYD, D.D. D.C.L. 8vo. 10*s.* 6*d.*

Elementary Treatise on the Wave-Theory of Light. By H. LLOYD, D.D. D.C.L. 8vo. 10*s.* 6*d.*

Text-Books of Science, Mechanical and Physical, adapted for the use of Artisans and of Students in Public and Science Schools. Small 8vo. with Woodcuts, &c.

Anderson's Strength of Materials, 3*s.* 6*d.*

Armstrong's Organic Chemistry, 3*s.* 6*d.*

Barry's Railway Appliances, 3*s.* 6*d.*

Bloxam's Metals, 3*s.* 6*d.*

Goodeve's Mechanics, 3*s.* 6*d.*

——— Mechanism, 3*s.* 6*d.*

Griffin's Algebra & Trigonometry, 3/6.

Jenkin's Electricity & Magnetism, 3/6.

Maxwell's Theory of Heat, 3*s.* 6*d.*

Merrifield's Technical Arithmetic, 3*s.* 6*d.*

Miller's Inorganic Chemistry, 3*s.* 6*d.*

Preece & Sivewright's Telegraphy, 3/6.

Shelley's Workshop Appliances, 3*s* 6*d.*

Thomé's Structural and Physiological Botany, 6*s.*

Thorpe's Quantitative Analysis, 4*s.* 6*d.*

Thorpe & Muir's Qualitative Analysis, price 3*s.* 6*d.*

Tilden's Systematic Chemistry, 3*s.* 6*d.*

Unwin's Machine Design, 3*s.* 6*d.*

Watson's Plane & Solid Geometry, 3/6.

*** Other Text-Books, in continuation of this Series, in active preparation.

The Comparative Anatomy and Physiology of the Vertebrate Animals. By RICHARD OWEN, F.R.S. With 1,472 Woodcuts. 3 vols. 8vo. £3. 13*s.* 6*d.*

Kirby and Spence's Introduction to Entomology, or Elements of the Natural History of Insects. Crown 8vo. 5*s.*

Light Science for Leisure Hours; Familiar Essays on Scientific Subjects, Natural Phenomena, &c. By R. A. PROCTOR, B.A. 2 vols. crown 8vo. 7*s.* 6*d.* each.

Homes without Hands; a Description of the Habitations of Animals, classed according to their Principle of Construction. By the Rev. J. G. WOOD, M.A. With about 140 Vignettes on Wood. 8vo. 14*s.*

Strange Dwellings; a Description of the Habitations of Animals, abridged from 'Homes without Hands.' By the Rev. J. G. WOOD, M.A. With Frontispiece and 60 Woodcuts. Crown 8vo. 7*s.* 6*d*

Insects at Home; a Popular Account of British Insects, their Structure, Habits, and Transformations. By the Rev. J. G. WOOD, M.A. With upwards of 700 Woodcuts. 8vo. price 14*s.*

Insects Abroad; being a Popular Account of Foreign Insects, their Structure, Habits, and Transformations. By the Rev. J. G. WOOD, M.A. With upwards of 700 Woodcuts. 8vo. 14*s.*

Out of Doors; a Selection of Original Articles on Practical Natural History. By the Rev. J. G. WOOD, M.A. With 6 Illustrations. Crown 8vo. 7*s.* 6*d.*

Bible Animals; a Description of every Living Creature mentioned in the Scriptures, from the Ape to the Coral. By the Rev. J. G. WOOD, M.A. With 112 Vignettes. 8vo. 14*s.*

The Polar World: a Popular Description of Man and Nature in the Arctic and Antarctic Regions of the Globe. By Dr. G. HARTWIG. With Chromoxylographs, Maps, and Woodcuts. 8vo. 10*s.* 6*d.*

The Sea and its Living Wonders. By Dr. G. HARTWIG. Fourth Edition, enlarged. 8vo. with numerous Illustrations, 10*s.* 6*d.*

The Tropical World. By Dr. G. HARTWIG. With about 200 Illustrations. 8vo. 10*s.* 6*d.*

The Subterranean World. By Dr. G. HARTWIG. With Maps and Woodcuts. 8vo. 10*s.* 6*d.*

The Aerial World; a Popular Account of the Phenomena and Life of the Atmosphere. By Dr. G. HARTWIG. With Map, 8 Chromoxylographs & 60 Woodcuts. 8vo. 21*s.*

Maunder's Treasury of Natural History, or Popular Dictionary of Animated Nature; in which the Zoological Characteristics that distinguish the different Classes, Genera and Species, are combined with a variety of interesting Information illustrative of the Habits, Instincts, and General Economy of the Animal Kingdom. Fcp. 8vo. with 900 Woodcuts, 6*s.*

A Familiar History of Birds. By E. STANLEY, D.D. late Bishop of Norwich. Fcp. 8vo. with Woodcuts, 3*s.* 6*d.*

Rocks Classified and Described. By B. VON COTTA. English Edition by P. H. LAWRENCE (with English, German, and French Synonymes), revised by the Author. Post 8vo. 14*s.*

The Geology of England and Wales; a Concise Account of the Lithological Characters, Leading Fossils, and Economic Products of the Rocks. By H. B. WOODWARD, F.G.S. Crown 8vo. Map & Woodcuts, 14*s.*

The Primæval World of Switzerland. By Professor OSWALD HEER, of the University of Zurich. Edited by JAMES HEYWOOD, M.A. F.R.S. President of the Statistical Society. With Map, 19 Plates, & 372 Woodcuts. 2 vols. 8vo. 28*s.*

The Puzzle of Life and How it Has Been Put Together: a Short History of Vegetable and Animal Life upon the Earth from the Earliest Times; including an Account of Pre-Historic Man, his Weapons, Tools, and Works. By A. NICOLS, F.R.G.S. With 12 Illustrations. Crown 8vo. 5*s.*

The Origin of Civilisation, and the Primitive Condition of Man; Mental and Social Condition of Savages. By Sir J. LUBBOCK, Bart. M.P. F.R.S. Third Edition, with 25 Woodcuts. 8vo. 18*s.*

The Ancient Stone Implements, Weapons, and Ornaments of Great Britain. By JOHN EVANS, F.R.S. With 2 Plates and 476 Woodcuts. 8vo. 28*s.*

The Elements of Botany for Families and Schools. Eleventh Edition, revised by THOMAS MOORE, F.L.S. Fcp. 8vo. Woodcuts, 2*s.* 6*d.*

The Rose Amateur's Guide. By THOMAS RIVERS. Latest Edition. Fcp. 8vo. 4*s.*

A Dictionary of Science, Literature, and Art. Re-edited by the late W. T. BRANDE (the Author) and the Rev. G. W. COX, M.A. 3 vols. medium 8vo. 63*s.*

The History of Modern Music, a Course of Lectures delivered at the Royal Institution of Great Britain. By JOHN HULLAH. Second Edition. Demy 8vo. 8*s.* 6*d.*

Mr. Hullah's 2nd Course of Lectures on the Transition Period of Musical History, from the Beginning of the Seventeenth to the Middle of the Eighteenth Century. Second Edition. Demy 8vo. 10*s.* 6*d.*

Structural and Physiological Botany. By OTTO W. THOMÉ, Professor of Botany at the School of Science and Art, Cologne. Translated and edited by A. W. BENNETT, M.A. B.Sc. F.L.S. Lecturer on Botany at St. Thomas's Hospital. With about 600 Woodcuts and a Coloured Map. Small 8vo. 6*s.*

The Treasury of Botany, or Popular Dictionary of the Vegetable Kingdom; with which is incorporated a Glossary of Botanical Terms. Edited by J. LINDLEY, F.R.S. and T. MOORE, F.L.S. With 274 Woodcuts and 20 Steel Plates. Two Parts, fcp. 8vo. 12*s.*

Loudon's Encyclopædia of Plants; comprising the Specific Character, Description, Culture, History, &c. of all the Plants found in Great Britain. With upwards of 12,000 Woodcuts. 8vo. 42*s.*

De Caisne & Le Maout's System of Descriptive and Analytical Botany. Translated by Mrs. HOOKER; edited and arranged according to the English Botanical System, by J. D. HOOKER, M.D. With 5,500 Woodcuts. Imperial 8vo. 31*s*. 6*d*.

Hand-Book of Hardy Trees, Shrubs, and Herbaceous Plants; containing Descriptions &c. of the Best Species in Cultivation. With 720 Original Woodcut Illustrations. By W. B. HEMSLEY. Medium 8vo. 12*s*.

CHEMISTRY and PHYSIOLOGY.

Miller's Elements of Chemistry, Theoretical and Practical. Re-edited, with Additions, by H. MACLEOD, F.C.S. 3 vols. 8vo.

PART I. CHEMICAL PHYSICS, New Edition in the press.
PART II. INORGANIC CHEMISTRY, 21*s*.
PART III. ORGANIC CHEMISTRY, New Edition in the press.

Health in the House: Twenty-five Lectures on Elementary Physiology in its Application to the Daily Wants of Man and Animals. By Mrs. C. M. BUCKTON. Crown 8vo. Woodcuts, 2*s*.

Outlines of Physiology, Human and Comparative. By J. MARSHALL, F.R.C.S. Surgeon to the University College Hospital. 2 vols. crown 8vo. with 122 Woodcuts, 32*s*.

An Introduction to the Study of Chemical Philosophy; or, the Principles of Theoretical and Systematic Chemistry. By W. A. TILDEN, F.C.S. Small 8vo. 3*s*. 6*d*.

Select Methods in Chemical Analysis, chiefly Inorganic. By WM. CROOKES, F.R.S. With 22 Woodcuts. Crown 8vo. 12*s*. 6*d*.

A Dictionary of Chemistry and the Allied Branches of other Sciences. By HENRY WATTS, F.C.S. assisted by eminent Scientific and Practical Chemists. 7 vols. medium 8vo. £10. 16*s*. 6*d*.

Supplementary Volume, completing the Record of Chemical Discovery to the year 1876.
[*In preparation.*

The FINE ARTS and ILLUSTRATED EDITIONS.

Poems. By W. B. SCOTT. Illustrated by Seventeen Etchings by L. A. TADEMA and W. B. SCOTT. Crown 8vo. 15*s*.

Half-hour Lectures on the History and Practice of the Fine and Ornamental Arts. By W. B. SCOTT. Cr. 8vo. Woodcuts, 8*s*. 6*d*.

A Dictionary of Artists of the English School: Painters, Sculptors, Architects, Engravers, and Ornamentists. By S. REDGRAVE. 8vo. 16*s*.

In Fairyland; Pictures from the Elf-World. By RICHARD DOYLE. With a Poem by W. ALLINGHAM. With 16 coloured Plates, containing 36 Designs. Folio, 15*s*.

Lord Macaulay's Lays of Ancient Rome. With 90 Illustrations on Wood from Drawings by G. SCHARF. Fcp. 4to. 21*s*.

Miniature Edition, with G. Scharf's 90 Illustrations reduced in Lithography. Imp. 16mo. 10*s*. 6*d*.

Moore's Lalla Rookh, TENNIEL'S Edition, with 68 Wood Engravings from Original Drawings. Fcp. 4to. 21*s.*

Moore's Irish Melodies, MACLISE'S Edition, with 161 Steel Plates. Super royal 8vo. 21*s.*

The New Testament, Illustrated with Wood Engravings after the Early Masters, chiefly of the Italian School. Crown 4to. 63*s.*

Sacred and Legendary Art. By Mrs. JAMESON. 6 vols. square crown 8vo. price £5. 15*s.* 6*d.*

Legends of the Saints and Martyrs. With 19 Etchings and 187 Woodcuts. 2 vols. 31*s.* 6*d.*

Legends of the Monastic Orders. With 11 Etchings and 88 Woodcuts. 1 vol. 21*s.*

Legends of the Madonna. With 27 Etchings and 165 Woodcuts. 1 vol. 21*s.*

The History of our Lord, with that of his Types and Precursors. Completed by Lady EASTLAKE. With 13 Etchings and 281 Woodcuts. 2 vols. 42*s.*

The Three Cathedrals dedicated to St. Paul in London; their History from the Foundation of the First Building in the Sixth Century to the Proposals for the Adornment of the Present Cathedral. By W. LONGMAN, F.S.A. With numerous Illustrations. Square crown 8vo. 21*s.*

The USEFUL ARTS, MANUFACTURES, &c.

The Amateur Mechanics' Practical Handbook; describing the different Tools required in the Workshop, the uses of them, and how to use them. By A. H. G. HOBSON. With 33 Woodcuts. Crown 8vo. 2*s.* 6*d.*

The Engineer's Valuing Assistant. By H. D. HOSKOLD, Civil and Mining Engineer, 16 years Mining Engineer to the Dean Forest Iron Company. 8vo. [*In the press.*

The Whitworth Measuring Machine; including Descriptions of the Surface Plates, Gauges, and other Measuring Instruments made by Sir J. WHITWORTH, Bart. By T. M. GOODEVE, M.A. and C. P. B. SHELLEY, C.E. Fcp. 4to. with 4 Plates and 44 Woodcuts. [*Nearly ready.*

Industrial Chemistry; a Manual for Manufacturers and for Colleges or Technical Schools; a Translation of Stohmann and Engler's German Edition of PAYEN'S 'Précis de Chimie Industrielle,' by Dr. J. D. BARRY. With Chapters on the Chemistry of the Metals, by B. H. PAUL, Ph.D. 8vo. Plates & Woodcuts. [*In the press.*

Gwilt's Encyclopædia of Architecture, with above 1,600 Woodcuts. Revised and extended by W. PAPWORTH. 8vo. 52*s.* 6*d.*

Lathes and Turning, Simple, Mechanical, and Ornamental. By W. H. NORTHCOTT. Second Edition, with 338 Illustrations. 8vo. 18*s.*

Hints on Household Taste in Furniture, Upholstery, and other Details. By C. L. EASTLAKE. With about 90 Illustrations. Square crown 8vo. 14*s.*

Handbook of Practical Telegraphy. By R. S. CULLEY, Memb. Inst. C.E. Engineer-in-Chief of Telegraphs to the Post-Office. 8vo. Plates & Woodcuts, 16*s.*

A Treatise on the Steam Engine, in its various applications to Mines, Mills, Steam Navigation, Railways and Agriculture. By J. BOURNE, C.E. With Portrait, 37 Plates, and 546 Woodcuts. 4to. 42*s.*

Recent Improvements in the Steam Engine. By J. BOURNE, C.E. Fcp. 8vo. Woodcuts, 6*s.*

Catechism of the Steam Engine, in its various Applications. By JOHN BOURNE, C.E. Fcp. 8vo. Woodcuts, *6s.*

Handbook of the Steam Engine By J. BOURNE, C.E. forming a Key to the Author's Catechism of the Steam Engine. Fcp. 8vo. Woodcuts, *9s.*

Encyclopædia of Civil Engineering, Historical, Theoretical, and Practical. By E. CRESY, C.E. With above 3,000 Woodcuts. 8vo. *42s.*

Ure's Dictionary of Arts, Manufactures, and Mines. Seventh Edition, re-written and enlarged by R. HUNT, F.R.S. assisted by numerous contributors. With 2,100 Woodcuts. 3 vols. medium 8vo. £5. 5*s.*

VOL. IV. Supplementary, completing all the Departments of the Dictionary to the beginning of the year 1877, is preparing for publication.

Practical Treatise on Metallurgy. Adapted from the last German Edition of Professor KERL'S Metallurgy by W. CROOKES, F.R.S. &c. and E. RÖHRIG, Ph.D. 3 vols. 8vo. with 625 Woodcuts. £4. 19*s.*

The Theory of Strains in Girders and similar Structures, with Observations on the application of Theory to Practice, and Tables of the Strength and other Properties of Materials. By B. B. STONEY, M.A. M. Inst. C.E. Royal 8vo. with 5 Plates and 123 Woodcuts, *36s.*

Treatise on Mills and Millwork. By Sir W. FAIRBAIRN, Bt. With 18 Plates and 322 Woodcuts. 2 vols. 8vo. *32s.*

Useful Information for Engineers. By Sir W. FAIRBAIRN, Bt. With many Plates and Woodcuts. 3 vols. crown 8vo. 31*s.* 6*d.*

The Application of Cast and Wrought Iron to Building Purposes. By Sir W. FAIRBAIRN, Bt. With 6 Plates and 118 Woodcuts. 8vo. *16s.*

Practical Handbook of Dyeing and Calico Printing. By W. CROOKES, F.R.S. &c. With numerous Illustrations and specimens of Dyed Textile Fabrics. 8vo. *42s.*

Anthracen; its Constitution, Properties, Manufacture, and Derivatives, including Artificial Alizarin, Anthrapurpurin, &c. with their Applications in Dyeing and Printing. By G. AUERBACH. Translated by W. CROOKES, F.R.S. 8vo. *12s.*

Mitchell's Manual of Practical Assaying. Fourth Edition, revised, with the Recent Discoveries incorporated, by W. CROOKES, F.R.S. Crown 8vo. Woodcuts, 31*s.* 6*d.*

Loudon's Encyclopædia of Gardening; comprising the Theory and Practice of Horticulture, Floriculture, Arboriculture, and Landscape Gardening. With 1,000 Woodcuts. 8vo. *21s.*

Loudon's Encyclopædia of Agriculture; comprising the Laying-out, Improvement, and Management of Landed Property, and the Cultivation and Economy of the Productions of Agriculture. With 1,100 Woodcuts. 8vo. *21s.*

RELIGIOUS and MORAL WORKS.

An Exposition of the 39 Articles, Historical and Doctrinal. By E. H. BROWNE, D.D. Bishop of Winchester. Latest Edition. 8vo. *16s.*

An Introduction to the Theology of the Church of England, in an Exposition of the 39 Articles. By T. P. BOULTBEE, LL.D. Fcp. 8vo. *6s.*

Historical Lectures on the Life of Our Lord Jesus Christ. By C. J. ELLICOTT, D.D. 8vo. 12*s.*

Sermons Chiefly on the Interpretation of Scripture. By the late Rev. THOMAS ARNOLD, D.D. 8vo. 7*s.* 6*d.*

Sermons preached in the Chapel of Rugby School; with an Address before Confirmation. By THOMAS ARNOLD, D.D. Fcp. 8vo. price 3*s.* 6*d.*

Christian Life, its Course, its Hindrances, and its Helps; Sermons preached mostly in the Chapel of Rugby School. By THOMAS ARNOLD, D.D. 8vo. 7*s.* 6*d.*

Christian Life, its Hopes, its Fears, and its Close; Sermons preached mostly in the Chapel of Rugby School. By THOMAS ARNOLD, D.D. 8vo. 7*s.* 6*d.*

Synonyms of the Old Tes-tament, their Bearing on Christian Faith and Practice. By the Rev. R. B. GIRDLESTONE. 8vo. 15*s.*

The Primitive and Ca-tholic Faith in Relation to the Church of England. By the Rev. B. W. SAVILE, M.A. 8vo. 7*s.*

The Eclipse of Faith; or a Visit to a Religious Sceptic. By HENRY ROGERS. Latest Edition. Fcp. 8vo. 5*s.*

Defence of the Eclipse of Faith. By HENRY ROGERS. Latest Edition. Fcp. 8vo. 3*s.* 6*d.*

Three Essays on Reli-gion: Nature; the Utility of Religion; Theism. By JOHN STUART MILL. 8vo. 10*s.* 6*d.*

A Critical and Gram-matical Commentary on St. Paul's Epistles. By C. J. ELLICOTT, D.D. 8vo. Galatians, 8*s.* 6*d.* Ephesians, 8*s.* 6*d.* Pastoral Epistles, 10*s.* 6*d.* Philippians, Colossians, & Philemon, 10*s.* 6*d.* Thessalonians, 7*s.* 6*d.*

The Life and Epistles of St. Paul. By Rev. W. J. CONYBEARE, M.A. and Very Rev. JOHN SAUL HOWSON, D.D. Dean of Chester. Three Editions, copiously illustrated.

Library Edition, with all the Original Illustrations, Maps, Landscapes on Steel, Woodcuts, &c. 2 vols. 4to. 42*s.*

Intermediate Edition, with a Selection of Maps, Plates, and Woodcuts. 2 vols. square crown 8vo. 21*s.*

Student's Edition, revised and condensed, with 46 Illustrations and Maps. 1 vol. crown 8vo. 9*s.*

Evidence of the Truth of the Christian Religion derived from the Literal Fulfilment of Prophecy. By ALEXANDER KEITH, D.D. 40th Edition, with numerous Plates. Square 8vo. 12*s.* 6*d.* or in post 8vo. with 5 Plates, 6*s.*

The Prophets and Pro-phecy in Israel; an Historical and Critical Inquiry. By Dr. A. KUENEN, Prof. of Theol. in the Univ. of Leyden. Translated from the Dutch by the Rev. A. MILROY, M.A. with an Introduction by J. MUIR, D.C.L. 8vo. 21*s.*

Mythology among the Hebrews and its Historical Development. By IGNAZ GOLDZIHER, Ph.D. Translated by RUSSELL MARTINEAU, M.A. 8vo. 16*s.*

Historical and Critical Commentary on the Old Testament; with a New Translation. By M. M. KALISCH, Ph.D. Vol. I. Genesis, 8vo. 18*s.* or adapted for the General Reader, 12*s.* Vol. II. Exodus, 15*s.* or adapted for the General Reader, 12*s.* Vol. III. Leviticus, Part I. 15*s.* or adapted for the General Reader, 8*s.* Vol. IV. Leviticus, Part II. 15*s.* or adapted for the General Reader, 8*s.*

The History and Literature of the Israelites, according to the Old Testament and the Apocrypha. By C. DE ROTHSCHILD & A. DE ROTHSCHILD. 2 vols. crown 8vo. 12*s.* 6*d.* Abridged Edition, 1 vol. fcp. 8vo. 3*s.* 6*d.*

Ewald's History of Israel. Translated from the German by J. E. CARPENTER, M.A. with Preface by R. MARTINEAU, M.A. 5 vols. 8vo. 63*s.*

Ewald's Antiquities of Israel. Translated from the German by H. S. SOLLY, M.A. 8vo. 12*s.* 6*d.*

Behind the Veil; an Outline of Bible Metaphysics compared with Ancient and Modern Thought. By the Rev. T. GRIFFITH, M.A. Prebendary of St. Paul's. 8vo. 10*s.* 6*d.*

The Trident, the Crescent & the Cross; a View of the Religious History of India during the Hindu, Buddhist, Mohammedan, and Christian Periods. By the Rev. J. VAUGHAN, Nineteen Years Missionary in India. 8vo. 9*s.* 6*d.*

The Types of Genesis, briefly considered as revealing the Development of Human Nature. By ANDREW JUKES. Crown 8vo. 7*s.* 6*d.*

The Second Death and the Restitution of all Things; with some Preliminary Remarks on the Nature and Inspiration of Holy Scripture. By A. JUKES. Crown 8vo. 3*s.* 6*d.*

History of the Reformation in Europe in the time of Calvin. By the Rev. J. H. MERLE D'AUBIGNÉ, D.D. Translated by W. L. R. CATES. 7 vols. 8vo. price £5. 11*s.*

VOL. VIII. translated by W. L. R. CATES, and completing the English Edition of Dr. D'AUBIGNÉ'S Work, is in the press.

Supernatural Religion; an Inquiry into the Reality of Divine Revelation. 2 vols. 8vo. 24*s.*

Commentaries, by the Rev. W. A. O'CONOR, B.A. Rector of St. Simon and St. Jude, Manchester.

Epistle to the Romans, crown 8vo. 3*s.* 6*d.*
Epistle to the Hebrews, 4*s.* 6*d.*
St. John's Gospel, 10*s.* 6*d.*

An Introduction to the Study of the New Testament, Exegetical, and Theological. By the Rev. S. DAVIDSON, D.D. LL.D. 2 vols. 8vo. 30*s.*

Passing Thoughts on Religion. By ELIZABETH M. SEWELL. Fcp. 8vo. 3*s.* 6*d.*

Thoughts for the Age. by ELIZABETH M. SEWELL. New Edition. Fcp. 8vo. 3*s.* 6*d.*

Some Questions of the Day. By ELIZABETH M. SEWELL. Crown 8vo. 2*s.* 6*d.*

Self-examination before Confirmation. By ELIZABETH M. SEWELL. 32mo. 1*s.* 6*d.*

Preparation for the Holy Communion; the Devotions chiefly from the works of Jeremy Taylor. By ELIZABETH M. SEWELL. 32mo. 3*s.*

Bishop Jeremy Taylor's Entire Works; with Life by Bishop Heber. Revised and corrected by the Rev. C. P. EDEN. 10 vols. £5. 5*s.*

Hymns of Praise and Prayer. Corrected and edited by Rev. JOHN MARTINEAU, LL.D. Crown 8vo. 4*s.* 6*d.* 32mo. 1*s.* 6*d.*

Spiritual Songs for the Sundays and Holidays throughout the Year. By J. S. B. MONSELL, LL.D. Fcp. 8vo. 5*s.* 18mo. 2*s.*

Lyra Germanica; Hymns translated from the German by Miss C. WINKWORTH. Fcp. 8vo. 5*s.*

Hours of Thought on Sacred Things; a Volume of Sermons. By JAMES MARTINEAU, D.D. LL.D. Crown 8vo. Price 7*s.* 6*d.*

Endeavours after the Christian Life; Discourses. By JAMES MARTINEAU, D.D. LL.D. Fifth Edition. Crown 8vo. 7*s.* 6*d.*

The Pentateuch & Book of Joshua Critically Examined. By J. W. COLENSO, D.D. Bishop of Natal. Crown 8vo. 6*s.*

Lectures on the Pentateuch and the Moabite Stone; with Appendices. By J. W. COLENSO, D.D. Bishop of Natal. 8vo. 12*s.*

TRAVELS, VOYAGES, &c.

A Year in Western France. By M. BETHAM-EDWARDS. Crown 8vo. Frontispiece, 10*s.* 6*d.*

Journal of a Residence in Vienna and Berlin during the eventful Winter 1805-6. By the late HENRY REEVE, M.D. Published by his SON. Crown 8vo. 8*s.* 6*d.*

One Thousand Miles up the Nile; a Journey through Egypt and Nubia to the Second Cataract. By AMELIA B. EDWARDS. With Facsimiles of Inscriptions, Ground Plans, Two Coloured Maps, and 80 Illustrations engraved on Wood from Drawings by the Author. Imperial 8vo. 42*s.*

The Indian Alps, and How we Crossed them: a Narrative of Two Years' Residence in the Eastern Himalayas, and Two Months' Tour into the Interior. By a Lady Pioneer. With Illustrations from Original Drawings by the Author. Imperial 8vo. 42*s.*

Discoveries at Ephesus, Including the Site and Remains of the Great Temple of Diana. By J. T. WOOD, F.S.A. With 27 Lithographic Plates and 42 Wood Engravings. Medium 8vo. 63*s.*

Through Bosnia and the Herzegovina on Foot during the Insurrection, August and September 1875. By ARTHUR J. EVANS, B.A. F.S.A. Second Edition. Map & Illustrations. 8vo. 18*s.*

Italian Alps; Sketches in the Mountains of Ticino, Lombardy, the Trentino, and Venetia. By DOUGLAS W. FRESHFIELD. Square crown 8vo. Illustrations, 15*s.*

Over the Sea and Far Away; a Narrative of a Ramble round the World. By T. W. HINCHLIFF, M.A. F.R.G.S. President of the Alpine Club. With 14 full-page Illustrations engraved on Wood. Medium 8vo. 21*s.*

The Frosty Caucasus; an Account of a Walk through Part of the Range, and of an Ascent of Elbruz in the Summer of 1874. By F. C. GROVE. With Eight Illustrations and a Map. Crown 8vo. price 15*s.*

Tyrol and the Tyrolese; an Account of the People and the Land, in their Social, Sporting, and Mountaineering Aspects. By W. A. BAILLIE GROHMAN. Crown 8vo. with Illustrations, 14*s.*

Two Years in Fiji, a Descriptive Narrative of a Residence in the Fijian Group of Islands. By LITTON FORBES, M.D. Crown 8vo. 8*s.* 6*d.*

Memorials of the Discovery and Early Settlement of the Bermudas or Somers Islands, from 1615 to 1685. By Major-General J. H. LEFROY, R.A. C.B. F.R.S. &c. Governor of the Bermudas. 8vo. with Map. [*In the press.*

Eight Years in Ceylon. By Sir SAMUEL W. BAKER, M.A. Crown 8vo. Woodcuts, 7*s.* 6*d.*

The Rifle and the Hound in Ceylon. By Sir SAMUEL W. BAKER, M.A. Crown 8vo. Woodcuts, 7*s.* 6*d.*

The Dolomite Mountains. Excursions through Tyrol, Carinthia, Carniola, and Friuli. By J. GILBERT and G. C. CHURCHILL, F.R.G.S. Square crown 8vo. Illustrations, 21*s.*

The Alpine Club Map of the Chain of Mont Blanc, from an actual Survey in 1863-1864. By A. ADAMS-REILLY, F.R.G.S. In Chromolithography, on extra stout drawing paper 10*s.* or mounted on canvas in a folding case 12*s.* 6*d.*

The Alpine Club Map of the Valpelline, the Val Tournanche, and the Southern Valleys of the Chain of Monte Rosa, from actual Survey. By A. ADAMS-REILLY, F.R.G.S. Price 6*s.* on extra stout drawing paper, or 7*s.* 6*d.* mounted in a folding case.

Untrodden Peaks and Unfrequented Valleys; a Midsummer Ramble among the Dolomites. By AMELIA B. EDWARDS. With numerous Illustrations. 8vo. 21*s.*

Guide to the Pyrenees, for the use of Mountaineers. By CHARLES PACKE. Crown 8vo. 7*s.* 6*d.*

The Alpine Club Map of Switzerland, with parts of the Neighbouring Countries, on the scale of Four Miles to an Inch. Edited by R. C. NICHOLS, F.R.G.S. In Four Sheets in Portfolio, price 42*s.* coloured, or 34*s.* uncoloured.

The Alpine Guide. By JOHN BALL, M.R.I.A. late President of the Alpine Club. Post 8vo. with Maps and other Illustrations.

The Eastern Alps, 10*s.* 6*d.*

Central Alps, including all the Oberland District, 7*s.* 6*d.*

Western Alps, including Mont Blanc, Monte Rosa, Zermatt, &c. Price 6*s.* 6*d.*

Introduction on Alpine Travelling in general, and on the Geology of the Alps. Price 1*s.* Either of the Three Volumes or Parts of the 'Alpine Guide' may be had with this Introduction prefixed, 1*s.* extra. The 'Alpine Guide' may also be had in Ten separate Parts, or districts, price 2*s.* 6*d.* each.

How to see Norway. By J. R. CAMPBELL. Fcp. 8vo. Map & Woodcuts, 5*s.*

WORKS of FICTION.

The Atelier du Lys; or an Art-Student in the Reign of Terror. By the author of 'Mademoiselle Mori.' Third Edition. Crown 8vo. 6*s.*

Novels and Tales. By the Right Hon. the EARL of BEACONSFIELD. Cabinet Editions, complete in Ten Volumes, crown 8vo. 6*s.* each.

Lothair, 6*s.*	Venetia, 6*s.*
Coningsby, 6*s.*	Alroy, Ixion, &c. 6*s.*
Sybil, 6*s.*	Young Duke &c. 6*s.*
Tancred, 6*s.*	Vivian Grey, 6*s.*

Henrietta Temple, 6*s.*
Contarini Fleming, &c. 6*s.*

Whispers from Fairyland. By the Right Hon. E. H. KNATCHBULL-HUGESSEN, M.P. With 9 Illustrations. Crown 8vo. 6*s.*

Higgledy-Piggledy; or, Stories for Everybody and Everybody's Children. By the Right Hon. E. H. KNATCHBULL-HUGESSEN, M.P. With 9 Illustrations. Crown 8vo. 6*s.*

Becker's Gallus; or Roman Scenes of the Time of Augustus. Post 8vo. 7*s.* 6*d.*

Becker's Charicles: Illustrative of Private Life of the Ancient Greeks. Post 8vo. 7*s.* 6*d.*

The Modern Novelist's Library.

Lothair. By the Rt. Hon. the EARL of BEACONSFIELD. Price 2*s.* boards; or 2*s.* 6*d.* cloth.

Atherstone Priory, 2*s.* boards; 2*s.* 6*d.* cloth.

Mlle. Mori, 2*s.* boards; 2*s.* 6*d.* cloth.

The Burgomaster's Family, 2*s.* & 2*s.* 6*d.*

MELVILLE'S **Digby Grand,** 2*s.* and 2*s.* 6*d.*

——— **General Bounce,** 2*s.* & 2*s.* 6*d.*

——— **Gladiators,** 2*s.* and 2*s.* 6*d.*

——— **Good for Nothing,** 2*s.* & 2*s.* 6*d.*

——— **Holmby House,** 2*s.* & 2*s.* 6*d.*

——— **Interpreter,** 2*s.* and 2*s.* 6*d.*

——— **Kate Coventry,** 2*s.* and 2*s.* 6*d.*

——— **Queen's Maries,** 2*s.* & 2*s.* 6*d.*

TROLLOPE'S **Warden,** 2*s.* and 2*s.* 6*d.*

——— **Barchester Towers,** 2*s.* & 2*s.* 6*d.*

BRAMLEY-MOORE'S **Six Sisters of the Valleys,** 2*s.* boards; 2*s.* 6*d.* cloth.

Elsa, a Tale of the Tyrolean Alps. Price 2*s.* boards; 2*s.* 6*d.* cloth.

Unawares, a Story of an old French Town. Price 2*s.* boards; 2*s.* 6*d.* cloth.

Stories and Tales. By

ELIZABETH M. SEWELL. Cabinet Edition, in Ten Volumes, each containing a complete Tale or Story :—

Amy Herbert, 2*s.* 6*d.*

Gertrude, 2*s.* 6*d.*

The Earl's Daughter, 2*s.* 6*d.*

Experience of Life, 2*s.* 6*d.*

Cleve Hall, 2*s.* 6*d.*

Ivors, 2*s.* 6*d.*

Katharine Ashton, 2*s.* 6*d.*

Margaret Percival, 3*s.* 6*d.*

Laneton Parsonage, 3*s.* 6*d.*

Ursula, 3*s.* 6*d.*

Tales of Ancient Greece.

By the Rev. G. W. COX, M.A. late Scholar of Trinity College, Oxford. Crown 8vo. 6*s.* 6*d.*

POETRY and THE DRAMA.

Milton's Lycidas. Edited,

with Notes and Introduction, by C. S. JERRAM, M.A. Crown 8vo. 2*s.* 6*d.*

Lays of Ancient Rome;

with Ivry and the Armada. By LORD MACAULAY. 16mo. 3*s.* 6*d.*

Lord Macaulay's Lays of

Ancient Rome. With 90 Illustrations on Wood from Drawings by G. SCHARF. Fcp. 4to. 21*s.*

Miniature Edition of Lord

Macaulay's Lays of Ancient Rome. with G. Scharf's 90 Illustrations reduced in Lithography. Imp. 16mo. 10*s.* 6*d.*

Horatii Opera. Library

Edition, with English Notes, Marginal References & various Readings. Edited by the Rev. J. E. YONGE, M.A. 8vo. price 21*s.*

Southey's Poetical

Works, with the Author's last Corrections and Additions. Medium 8vo. with Portrait, 14*s.*

Beowulf, a Heroic Poem

of the Eighth Century (Anglo-Saxon Text and English Translation), with Introduction, Notes, and Appendix. By THOMAS ARNOLD, M.A. 8vo. 12*s.*

Poems by Jean Ingelow.

2 vols. fcp. 8vo. 12*s.*

FIRST SERIES, containing 'Divided,' 'The Star's Monument,' &c. Fcp. 8vo. 5*s.*

SECOND SERIES, 'A Story of Doom,' 'Gladys and her Island,' &c. 5*s.*

Poems by Jean Ingelow.

First Series, with nearly 100 Woodcut Illustrations. Fcp. 4to. 21*s.*

The Iliad of Homer, Homometrically

translated by C. B. CAYLEY, Translator of Dante's Comedy, &c. 8vo. 12*s.* 6*d.*

The Æneid of Virgil.

Translated into English Verse. By J. CONINGTON, M.A. Crown 8vo. 9*s.*

Bowdler's Family Shakspeare.

Cheaper Genuine Edition, complete in 1 vol. medium 8vo. large type, with 36 Woodcut Illustrations, 14*s.* or in 6 vols. fcp. 8vo. 21*s.*

RURAL SPORTS, HORSE and CATTLE MANAGEMENT, &c.

Annals of the Road; or, Notes on Mail and Stage-Coaching in Great Britain. By Captain MALET, 18th Hussars. To which are added Essays on the Road, by NIMROD. With 3 Woodcuts and 10 Coloured Illustrations. Medium 8vo. 21*s.*

Down the Road; or, Reminiscences of a Gentleman Coachman. By C. T. S. BIRCH REYNARDSON. Second Edition, with 12 Coloured Illustrations. Medium 8vo. 21*s.*

Blaine's Encyclopædia of Rural Sports; Complete Accounts, Historical, Practical, and Descriptive, of Hunting, Shooting, Fishing, Racing, &c. With above 600 Woodcuts (20 from Designs by J. LEECH). 8vo. 21*s.*

A Book on Angling; or, Treatise on the Art of Fishing in every branch; including full Illustrated Lists of Salmon Flies. By FRANCIS FRANCIS. Post 8vo. Portrait and Plates, 15*s.*

Wilcocks's Sea-Fishermen: comprising the Chief Methods of Hook and Line Fishing, a glance at Nets, and remarks on Boats and Boating. Post 8vo. Woodcuts, 12*s.* 6*d.*

The Fly-Fisher's Entomology. By ALFRED RONALDS. With 20 Coloured Plates. 8vo. 14*s.*

Horses and Stables. By Colonel F. FITZWYGRAM, XV. the King's Hussars. With 24 Plates of Illustrations. 8vo. 10*s.* 6d.

Youatt on the Horse. Revised and enlarged by W. WATSON, M.R.C.V.S. 8vo. Woodcuts, 12*s.* 6*d.*

Youatt's Work on the Dog. Revised and enlarged. 8vo. Woodcuts, 6*s.*

The Dog in Health and Disease. By STONEHENGE. With 73 Wood Engravings. Square crown 8vo. 7*s.* 6*d.*

The Greyhound. By STONEHENGE. Revised Edition, with 25 Portraits of Greyhounds, &c. Square crown 8vo. 15*s.*

Stables and Stable Fittings. By W. MILES. Imp. 8vo. with 13 Plates, 15*s.*

The Horse's Foot, and How to keep it Sound. By W. MILES. Imp. 8vo. Woodcuts, 12*s.* 6*d.*

A Plain Treatise on Horse-shoeing. By W. MILES. Post 8vo. Woodcuts, 2*s.* 6*d.*

Remarks on Horses' Teeth, addressed to Purchasers. By W. MILES. Post 8vo. 1*s.* 6*d.*

The Ox, his Diseases and their Treatment; with an Essay on Parturition in the Cow. By J. R. DOBSON, M.R.C.V.S. Crown 8vo. Illustrations, 7*s.* 6*d.*

WORKS of UTILITY and GENERAL INFORMATION.

Maunder's Treasury of Knowledge and Library of Reference; comprising an English Dictionary and Grammar, Universal Gazetteer, Classical Dictionary, Chronology, Law Dictionary, Synopsis of the Peerage, Useful Tables, &c. Fcp. 8vo. 6*s*.

Maunder's Biographical Treasury. Latest Edition, reconstructed and partly re-written, with above 1,600 additional Memoirs, by W. L. R. CATES. Fcp. 8vo. 6*s*.

Maunder's Scientific and Literary Treasury; a Popular Encyclopædia of Science, Literature, and Art. Latest Edition, in part re-written, with above 1,000 new articles, by J. Y. JOHNSON. Fcp. 8vo. 6*s*.

Maunder's Treasury of Geography, Physical, Historical, Descriptive, and Political. Edited by W. HUGHES, F.R.G.S. With 7 Maps and 16 Plates. Fcp. 8vo. 6*s*.

Maunder's Historical Treasury; General Introductory Outlines of Universal History, and a Series of Separate Histories. Revised by the Rev. G. W. COX, M.A. Fcp. 8vo. 6*s*.

Maunder's Treasury of Natural History; or, Popular Dictionary of Zoology. Revised and corrected Edition. Fcp. 8vo. with 900 Woodcuts, 6*s*.

The Treasury of Bible Knowledge; being a Dictionary of the Books, Persons, Places, Events, and other Matters of which mention is made in Holy Scripture. By the Rev. J. AYRE, M.A. With Maps, Plates, and many Woodcuts. Fcp. 8vo. 6*s*.

A Practical Treatise on Brewing; with Formulæ for Public Brewers & Instructions for Private Families. By W. BLACK. 8vo. 10*s*. 6*d*.

Chess Openings. By F. W. LONGMAN, Balliol College, Oxford. Second Edition. Fcp. 8vo. 2*s*. 6*d*.

English Chess Problems. Edited by J. PIERCE, M.A. and W. T. PIERCE. With 608 Diagrams. Crown 8vo. 12*s*. 6*d*.

The Theory of the Modern Scientific Game of Whist. By W. POLE, F.R.S. Eighth Edition. Fcp. 8vo. 2*s*. 6*d*.

The Correct Card; or, How to Play at Whist; a Whist Catechism. By Captain A. CAMPBELL-WALKER, F.R.G.S. New Edition. Fcp. 8vo. 2*s*. 6*d*.

The Cabinet Lawyer; a Popular Digest of the Laws of England, Civil, Criminal, and Constitutional. Twenty-Fourth Edition, corrected and extended. Fcp. 8vo. 9*s*.

Pewtner's Compre-hensive Specifier; a Guide to the Practical Specification of every kind of Building-Artificer's Work. Edited by W. YOUNG. Crown 8vo. 6*s*.

Hints to Mothers on the Management of their Health during the Period of Pregnancy and in the Lying-in Room. By THOMAS BULL, M.D. Fcp. 8vo, 2*s*. 6*d*.

The Maternal Manage-ment of Children in Health and Disease. By THOMAS BULL, M.D. Fcp. 8vo. 2*s*. 6*d*.

The Treasury of Botany, or Popular Dictionary of the Vegetable Kingdom; with which is incorporated a Glossary of Botanical Terms. Edited by J. LINDLEY, F.R.S. and T. MOORE, F.L.S. With 274 Woodcuts and 20 Steel Plates. Two Parts, fcp. 8vo. 12*s*.

Modern Cookery for Private Families, reduced to a System of Easy Practice in a Series of carefully-tested Receipts. By ELIZA ACTON. With 8 Plates and 150 Woodcuts. Fcp. 8vo. *6s.*

The Elements of Banking. By H. D. MACLEOD, M.A. Second Edition. Crown 8vo. *7s. 6d.*

The Theory and Practice of Banking. By H. D. MACLEOD, M.A. 2 vols. 8vo. 26s.

Our New Judicial System and Civil Procedure as Reconstructed under the Judicature Acts, including the Act of 1876; with Comments on their Effect and Operation. By W. F. FINLASON, Barrister-at-Law. Crown 8vo. 10*s.* 6*d.*

Willich's Popular Tables for ascertaining, according to the Carlisle Table of Mortality, the value of Lifehold, Leasehold, and Church Property, Renewal Fines, Reversions, &c. Also Interest, Legacy, Succession Duty, and various other useful Tables. Eighth Edition. Post 8vo. 10*s.*

INDEX.

[*Continued.*

Spottiswoode & Co., Printers, New-street Square, London.